A PRIMER OF TIME STUDY

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INTRODUCTION

This book was prepared for those who are interested in time-measurement procedure as applied to industrial operations and is based on the use of the stop watch as a means of establishing standard time and energy values for the various machine and manual labor elements incidental to such operations.

As a primer this book will assume that time-study practice is a new subject to the reader and so the approach to it is made in an elementary manner. To that end, and for the subsequent treatment of the more advanced principles involved, the text is divided into twenty-four chapters to be considered as lessons to be mastered by the reader.

In none of the chapters is an outline given covering the early history of the stop watch and methods used by the pioneers who paved the way toward the present-day industrial manufacturing activities. Although it is not essential, if the reader wishes to inform himself regarding the development of time-study work up to the point of this book, he may be able to obtain from his city library certain earlier books relating to phases of that subject.

Despite the fact that you as a reader of this primer may possess prior knowledge of time study, it is recommended that you not only read it in a deliberate manner but also check your full understanding of the text by answering in written form the examination questions and problems given for each chapter. Presupposing you will do this, a few suggestions are offered.

Successfully to complete the entire text requires the setting aside of a certain amount of time each day regularly devoted to study. The more time spent on the text, the sooner it will be mastered. It would seem, therefore, that your first step toward completion of this book is to establish study periods based on definite daily schedules.

Your present daily routine allows time for dressing, shaving, eating, working, sleeping, and many other things including recreation. It is a part of your recreation or leisure periods that must be used for the study and understanding of this primer.

We do not presume to say that all people enjoy intensive study schedules. Some are so constituted that they find pleasure in studying; others consider it a task. Whether mental application is a recreation or a task, periods of time for study should be definitely incorporated as a regular habit in the pattern of your daily existence.

Habit is a developed tendency to act in certain directions. If you have habits that contribute to your general welfare, these habits are a part of your life. The study habit is also a practice to be developed. Just as you set aside time to eat, so should you schedule time for study. If unavoidable things occur that interfere with one day's study period, the next day's program should be lengthened to compensate for the previous handicap.

Your daily practice of shaving may not be classed as a pleasure; yet it is one of your necessary habits for which time is allowed. You would not think of letting one day pass by without eating; neither should you neglect or omit the habit of study.

Someone has aptly said that all worth-while things in life must be sought and then attained by persistent endeavor. The real things of life do not fall into your lap—they must be secured by hard work.

The present captains of industry would not have had their jobs given to them unless they were mentally capable. Some of the most successful executives did not finish grade school; yet they possess intellects so keen that they have no trouble in meeting the perplexing problems constantly arising in the pursuit of their work. In place of formal education secured from colleges these men developed their mental capacities through books, or by other methods of home study for self-improvement. To arrive at their goals they had to study. With them study is a habit. That regular habit is an integral part of their lives.

This book will most assuredly broaden your ability and equip you with the training to meet and dispose of problems pertaining to time-study work—provided, of course, that you faithfully study and comply with the requirements of the entire contents.

Your brain is similar to the muscular parts of your anatomy. If you use it constantly, it becomes as proportionately strong as any other part of your body regularly used. One reason why graduates from colleges absorb new ideas so quickly is that they have been trained to think. To think properly, they studied under rigid schedules which developed their minds to the point

where the absorption of new ideas becomes much easier than in the case of those who do not exercise their brains.

Reading light fiction or other printed matter that requires no mental effort does not stimulate your brain. It is that reading which taxes your mental perception that strengthens your power of analysis and ability to absorb further education.

If you as a reader have been used to study, you will find that the full understanding of this book will not be so difficult as if you have been out of school or have not studied for a number of years. In the latter case, concentration will at first prove to be a much harder mental task. However, if you faithfully follow a set routine of study, your mind will quickly respond and you will discover that your power of analysis and assimilation of knowledge will soon become an easy task.

You will find the chapters interesting because the principles contained in them have been successfully demonstrated in many diversified types of manufacturing industries in many parts of the United States. The examples and problems are concrete and can be directly or indirectly applied to your time-study problems. The various statements made are not advanced as academic theories but are stated as facts actually tried and proved many times. The twenty-four chapters are so integrated that they form a continuous story. To know thoroughly the laws and principles given in this primer, every chapter must be mastered.

No attempt is made to prejudice the reader in favor of any particular system. You will find that piecework, premium, and group plans are all impartially treated. It is believed this primer will teach you not only the fundamentals but the advanced stages of time-study work that will enable you to handle any wage-payment incentive plan. It hopes to give you that "groundwork" so sadly lacking in many time-study men. Once you have made up your mind to "see it through," the next steo is to arrange for a place of study.

We suggest a quiet room away from disturbing noises. It is the outside influences that pull your mind away from your mental concentration. If the reader can get away from disquieting interruptions, he can progress much faster.

In order to study properly, your table, chair, and illumination should be considered for your physical comfort. An uncomfortable chair or the glare of a strong light induces a fatigue that

may be greater than that resulting from prolonged study periods. The table should be large enough not only to contain the immediate books and papers engaging your attention but also to hold the rest of your time-study equipment. If all your materials are within arm's reach, there is a greater incentive to study than if you must carefully collect your data each day and place them elsewhere in your home. In a few words: if you will make your study spot attractive and convenient, you will find greater pleasure and accomplish more when observing your study schedules.

A method of study should next be settled. We suggest that you confine yourself to only one chapter at a time, *i.e.*, start and finish one chapter before beginning the next. To complete a chapter properly, you should first read it through casually to learn of its general import. Afterward, read it through very slowly and digest all the statements made. We have tried to make each statement as brief as possible consistent with clarity, instead of expanding the various laws and principles into lengthy descriptions. Since the paragraphs are made as concise as advisable, they must be read in a careful manner. It is recommended that you pay particular attention to the many examples given to amplify the different laws and principles. These examples were selected with a great amount of care and should be applicable to many of your time-study perplexities.

Throughout the book there are many formulas, tables, charts, and other time-measurement data that may be officially used by the reader in his commercial time-study work. These data, if official, are stated as such. Other data used in the examples and problems are only approximate figures correctly used for illustrative purposes and should not be used for comparisons with actual time-study data you may compile in industrial practice.

At the end of each chapter is a series of questions and problems to be answered in written form by you and later compared with the master answers also incorporated in the primer for your guidance. Your problem papers after self-grading can be kept for future reference. Reducing your solutions to written form is urged in order that you may intelligently check them with the master answers. The various examination questions asked are easy to answer since they concern the more significant points out-

lined in each chapter. Most of the questions asked are to ensure your rereading of some of the pages covering the major principles, and to require you to reduce these important points to writing. The answer of "Yes" or "No" alone to a question should not be given. A brief statement should give the reasons for your negative or affirmative reply. Sometimes when answering certain questions it is well to suppose that some skeptic has asked the question and in your efforts to convert him to your way of thinking, your replies have to be made in a most convincing manner.

Your problem papers should be graded by a simple system. A problem credit must be made up of at least two factors: correctness of theory and accuracy of figuration. If the examination consists of ten questions and problems, each one is given ten points for accurate solution. If on one problem your theory is correct but a mistake is made in figuration due to an obvious error in slide-rule reading, addition, subtraction, etc., a credit of five or more points can be awarded for that particular problem. A misplaced decimal point in the final answer of a problem calls for a zero credit regardless of how accurate otherwise the figuration and theory may be. Of course, in your professional life accuracy is more important than theory, but in order to reach that stage of seasoned professional training, small inaccuracies of figuration can be tolerated, at least from the standpoint of some of the problems, if such errors are not due to mistaken theories.

The total number of required answers and solutions for certain of the examinations is 4, 5, 10, or 20. Thus, each correct individual answer or solution for such series is granted, respectively, 25, 20, 10, and 5 points of credit. An average credit of seventy points for the twenty-four chapters is considered as the minimum passing grade.

It is hoped that each reader will master the primer in written form as recommended and that in being fully honest with himself he will not attempt to consult the model answers at the end of every chapter until his papers for that chapter have been completed. Otherwise, his conscience may tell him his self-appointed credits were too high.

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CONTENTS

Chapter I

We consider this chapter the most important one in the entire book, particularly Part II, Qualifications for Time-study Men. This chapter should be read carefully and slowly. Afterward, a detailed study should be made of each of the 24 qualities.

With reference to those qualities, we cannot emphasize too strongly how important it is that each one of them be developed to a high degree. The Capacity Chart clearly indicates why the time-study man's qualities should be higher than the equivalent ones of the average executive. Since there are 24 chapters and the same number of inherent and acquired qualities, we suggest that you review a quality each time you start a new chapter. This will mean that Chap. I will be referred to 24 times during the reading of the book.

The subject matter of each quality is quite brief—volumes might be written on any one of them. Our brief treatment of each quality should encourage you to seek suitable books from your public library to supplement the short outlines given, because the 80%–20% ratio statement made in this first chapter is a conservative appraisal of the relation between contact and education but emphasizes the value of the former.

Almost any man of average intelligence can, in the fullness of time, master the mechanics of time-study work, but to sell and keep sold his findings requires a knowledge of human engineering broad enough to deal with individuals ranging all the way from the unskilled laborer to the topmost man in management. Education and common sense will produce accurate time studies, but an ability of greater magnitude is needed to meet successfully the human problems encountered in time-study work. That ability is contact.

CHAPTER I

OUTLOOK AND REQUISITES FOR TIME STUDY

PART I. TIME-STUDY POSSIBILITIES

Time study may be properly termed a science. Webster's Dictionary defines science as follows:

> "*Science.*—Any branch of systematized knowledge considered as a distinct field of investigation or object of study."

Limiting our field of investigation to the industrial side of the economic world, we may then have this definition:

> *Time study.*—A science covering the true measurement of time, as applied to industry, in which proper machine performance, methods, human endeavor, and conditions surrounding them are studied for the purpose of analysis and standardization.

The successful conduct of any business requires exact information covering every detail of its operation. This information must be unqualifiedly accurate. It must be obtained simply and must be complete enough to give to the persons responsible for the operation of the business a thorough knowledge of its every detail. The possession of such exact information alone enables the industrial executive to eliminate waste, to transform it into profitable by-products, and to minimize the damage, wear, and tear that occur in every industrial plant.

MACHINERY

To meet constantly changing conditions, new machines are periodically necessary. Such machines are based on definite mechanical laws. The entire march of modern industry has been dominated by the invention of new and ever more efficient machinery. Each year science adds new types which displace those made obsolete or inferior by reason of the advanced performance of the new mechanical wonders. Such development,

modification, or modernization is unavoidable for the business which would meet the challenge of new and constantly expanding means of production.

Years ago, the power to drive machinery was obtained from man, animal, or water power. Today, machinery is moved by steam, hydraulic, oil, gas, gasoline, or electrical power. Tomorrow, machinery may receive its motivating force from the sun's rays, from the tides, from some new form of electrical energy, or from other mysterious sources as yet undiscovered. All these forces are subject to mechanical laws.

New machinery will be developed for economy, accuracy, quality of product, ease of operation, or more efficient design. No matter what state of perfection machinery may ultimately attain, its progress and its mastery will pay undeviating tribute to scientific analysis. Thus, time-study analysis plays a major role in the creation of new machines and a most important part in their successful operation.

METHODS

The manufacture of any product consists of one or more operations necessary to convert the article from the raw to the finished state. These operations are completed by means of at least two fundamental methods: (1) with machinery, and (2) without machinery. The first method may be subdivided into three groups:

1*a*. With machinery, where the design is so nearly automatic that very little human assistance is needed to keep it in almost continuous operation. *Examples:* automatic screw machines, gear cutters, cigarette machiners, candy machines.

1*b*. With machinery, where the machine sets the pace yet is more dependent upon human assistance for its performance. *Examples:* semiautomatic machines, mechanically paced moving belts, conveyors.

1*c*. With machinery, where the machine is entirely dependent upon human assistance and therefore cannot set the pace. *Examples:* hand-feed drill presses, farm implements, air hammers and other hand-operated power-driven machines.

2. Without machinery, where, in the absence of machines, the output is dependent upon human endeavor.

HUMAN ENDEAVOR

One of the most interesting phases of time-study work is human engineering, or the study of labor. By labor, we mean the whole

range of human beings from those performing the most menial of tasks at the lowest end of the scale to the most brilliant of persons at the opposite end of the scale. Labor is used in everything about us. No matter how nearly automatic a machine may be, it will require human assistance in some degree to keep it in productive operation.

The study and analysis of human beings are so involved that volumes have been written in the attempt to reduce mankind to some common denominator. Psychologists, social scientists, character analysts, and a host of others have developed countless theories and hypotheses from which they have projected their respective rules or measurements.

Although results have occasionally been achieved of genuine interest to the realm of pure science, it is only fair to point out that such studies have not as yet produced any factors of knowledge which are applicable to applied science as manifested in our industrial life. It must be kept in mind, therefore, that time study in measuring the individual worker in relation to his job keeps close to recognized facts and avoids all speculative or incomplete fields of knowledge.

The effectiveness of the individual worker is determined by his personal characteristics. These include such things as temperament, skill, effort, intelligence, experience, physical strength, endurance, and resourcefulness.

One or more of these characteristics is required on every job, regardless of how simple the job may be. Some workers may possess only a few of them, others may possess all of them, but in any one case will be found varying degrees of these characteristics. It is possible to improve certain characteristics already present and to acquire others known to be lacking. It is needless to state that when many of these characteristics are present in high degree in any one person, they place him on a level far above the average classification.

Time study does not attempt to search out every man's strength or weakness and reduce them to the common denominator previously mentioned. However, in the study and analysis of some given job, it does reveal the characteristics necessary for the proper completion of that job. It may not be able to express their exact percentage; nevertheless, it can arrive at the qualifications required for the job.

Thus, we may say: *Time study measures the requirements for the task and then judges the worker now on that task.*

CONDITIONS

Many jobs have some disturbing elements connected with them that prevent an ideal situation. From the standpoint of the worker, an analysis will show that he is handicapped by conditions surrounding his work. Some of these conditions may be undue heat or cold, wetness, darkness, poor ventilation, fumes, improper working posture, nervous or physical strain, or perhaps a dangerous type of work.

A worker also may be handicapped because of old machinery, tools, buildings, or lack of uniformity in material. He may be required to do preparation work before starting his prescribed duties or may have other delays and interferences too numerous to mention at this point.

Time study will reveal the need for rest factors or personal allowances and will determine additional time allowances for all other things in the conditions that are beyond the control of the worker.

Referring to the definition on page 3, we have thus far treated, in a brief way: machinery, methods, human endeavor, and conditions. These four items cover the problem of converting raw material into the finished state. Attending these items are such things as materials, tools, buildings, equipment, etc., which should rightfully enlarge the group, but for our purpose in the subsequent chapters, we shall consider them as a part of the four items unless occasion demands separate treatment in given instances.

As outlined under Methods on page 4 in items 1*a* and 1*b*, labor appears to be only incidental to the machine, whereas in 1*c* and 2 labor becomes the most important factor and therefore sets the pace. We may then assume that labor is the most important of the four items and consequently should be dealt with thoroughly.

A correct time study consists of a study of the product to be made, dividing the process into operations, subdividing the operations into proper elements, and recognizing all things connected with the elements—to time accurately each proper element for the purpose of analysis and standardization.

The word "Standardization" is intended to embrace a model manner in which a task is accomplished, using the proper machinery and the most desirable methods under average conditions where both costs and labor are satisfied.

Time study does not become a secret document confined to the use of the plant management. It is an accurate group of data that covers the best and most efficient manner of completing a job under given conditions. It becomes a set of instructions used by the foremen and executives in arriving at ideal conditions and also by the workers in pursuit of their duties. Since it specifies the measurement of time the time allowances must be correct and subject to proof. The workers should be shown the data found and all details should be freely discussed with them, proving any or all of the elements which may be questioned, and, in general, answering any queries surrounding the job. Any air of mystery, uncertainty, or prejudice that might be associated with time-study findings or conclusions should be dispelled by frank discussions of its benefits to all concerned.

Only persons having skill, training, and thorough ability should attempt time study. Its success yields wonderful results, while its failure causes heartaches beyond words.

A person should be trained before he attempts to use a double-entry bookkeeping system. If he is not trained and fails, the system is not indicted, but the untrained bookkeeper is. There is no law to prevent an unskilled man from purchasing a set of surgeon's tools, yet one would shudder to think of the results if he attempted delicate surgery. By the same token, there is no ruling that prevents an untrained person from using a stop watch although his use of it in industry is probably as dangerous as giving a loaded pistol to a child.

During the World War when industry was speeded up and conditions became abnormal, attempts, successful and otherwise, were made to use the stop watch. The unsuccessful ones were generally traced to the use of the watches by untrained men who created a great amount of trouble because of their lack of skill.

Workers were timed from behind posts or other vantage points, much as a hunter behind a tree would stalk game. The workers were nearly always aware of this and often doubled the length of time they ordinarily required to complete their operations, since

they knew full well that the time allowance would be cut in half by the time it reached them in the form of the particular incentive system under which they were working.

These practices led to a game of matching wits. Whenever time-study men or any unknown persons entered the plant, they were promptly labeled "efficiency experts" and a bitter feeling arose against these intruders.

Before the World War there were a few reputable firms who had trained men on their staffs engaged in time-study work. Manufacturing plants suffering from the bad effects of improper plant morale secured their services. Even with this expert assistance, the workers in numbers of cases responded to the trained engineers' efforts with the same attitude of distrust that they had manifested toward their common enemy, the efficiency expert.

Manufacturers now know that labor must be loyal, well paid, and content. They also know that their products must be accurate as to quality and finish and made rapidly and economically. They are realizing more and more that this new science of time study yields satisfaction to both management and labor and enables both to keep their place in the fast-moving conditions of today.

Newspapers and magazines often contain lengthy articles condemning this so-called high-speed era of today. Writers, lecturers, and students of social science deplore the trend of the times. They speculate as to the probable results of this frenzied, nerve-racking haste. They point out the futility, or penalty of

The machine's replacing the man.
Speed required in automobile and other industries.
Speeded-up railroad, bus, and airplane schedules.
Faster boats to cut time in ocean travel.
Radios operating on split-second programs.
Driving motor cars at unnecessarily high speeds.
Anger at slow-operating traffic lights.
Impatience over delayed telephone connections.

These same commentators state that the average person eats too rapidly, does not think but relies on headlines or the pictures in tabloids for his mental nourishment, and, in general, is a bundle of nerves. Perhaps they are correct in their observations;

perhaps we should slow down and become more deliberate in each of our 24-hr. days. Nevertheless, the industrial life in all the leading nations is moving at a pace which seems to grow faster each year.

The whole world of industry may be envisaged as a moving machine receiving its impetus from a train of gears, each country represented by a gear of given size corresponding to the country's industrial contribution to the rest of the world. So far, the American gear is of such size as to serve as a most important member of the machine. To change it without affecting the machine as a whole would mean the adjustment of the other gears to overcome the deficiency. Truly, this is an age of the "survival of the fittest."

The complexities arising from world-wide changes compel every manufacturer to plan constantly to meet changing conditions. Competition that offers higher quality or lower selling prices must be met. Articles made under mass-production methods with narrow margins of profit must be produced at low manufacturing costs that can be controlled.

The American worker receives higher wages than the worker in any other part of the world. Consequently, the output per man must be very high in this country. No man objects to a full day's work if paid for it. The full day's work should be found through time study. The pay should be determined from a wage-payment or incentive plan designed to meet the requirements of each particular company or task.

There are many excellent incentive plans that reward labor for the effort expended and accomplishments attained. The application of a plan should cover as many as possible of the direct and indirect workers in a plant so that all may participate in increased earnings. Thus, the plan selected should be flexible enough to permit of incentives to both direct and indirect workers and also to meet the different problems that accrue from diversified operations in many different kinds of manufacturing departments.

The use of a combination time study and a successfully developed incentive or wage plan will bring about many things to meet the changing conditions mentioned above. Among them are

Increased earnings for employees.
More output per unit of time.
Lower direct and indirect costs.
Increased morale of employees.
Lower labor turnover.
Improved quality and precision of work.
Lower percentage of spoiled work.
Better control of production.
Better control of costs.
Maintenance of profit margins.
Flexibility to meet competition.

PART II. QUALIFICATIONS FOR TIME-STUDY MEN

In outlining a set of specifications setting forth the desired qualifications for a time-study man, it might at first appear that the attributes demanded would be impossible for any average man to possess and would consequently limit the field of candidates to supermen. Despite the apparently formidable list of talents given on page 11, any average man will find that he already has most of them in some degree.

Regardless of the profession followed, most of the characteristics will be found necessary if permanent success is to be achieved. The greater the success, the more these highly developed characteristics will be found as contributing factors.

Any ambitious man is frankly critical of himself and will try to overcome any undesirable tendencies of which he may be aware. He will fortify himself with a broader education along the lines of his work and will try to develop talents or characteristics known to be lacking. This, perhaps, does not apply to the confirmed egotist but it does to the average person who feels that self-improvement is imperative for his welfare. A conscientious person will be his own severest critic and will consider any constructive means to get ahead.

The time-study man occupies an important place in industry. He may remain at a given level for years unless he constantly improves himself. Many time-study men remain in the thirty-five-dollar-a-week class, whereas others become so valuable that they soon advance to the highest positions in industry.

The following list of the time-study man's qualifications is given:

INHERENT AND ACQUIRED QUALITIES

1. Honesty
2. Personality
3. Imagination
4. Sense of fairness
5. Open-mindedness
6. Power of sympathy
7. Tact
8. Resourcefulness
9. Reliability
10. Self-control
11. Energy
12. Proper conduct
13. Self-confidence
14. Cooperation
15. Sense of responsibility
16. Observation
17. Analysis
18. Judgment
19. Accuracy
20. Planning ability
21. Power of instruction
22. Optimism
23. Salesmanship
24. Leadership

Inherent qualities are those already possessed. They are native or inborn, but subject to cultivation by proper treatment. They are often intangible and defy accurate measurement. Acquired qualities are those attained by one's own exertions, the acquisition of which broadens one's capacity.

It is believed that the make-up of a good time-study man is comprised of a percentage of 80% – 20%. The 80 per cent can be called contact. The other 20 per cent may be called education and common sense. A time-study man (hereafter abbreviated by use of the letters T.S.M.) might be equipped with the 20 per cent make-up and fail miserably. Despite his brilliance and common sense, he would not reach first base without contact.

Mechanical ability has been left out of the list of the qualities. A good T.S.M. need not have a thorough mechanical ability to do his job accurately, although any experience he may have had on the task he is analyzing will be of benefit to him. The president of a successful automobile factory does not necessarily have to be a composite of the fastest or most skillful operators on every job in the organization.

1. Honesty.—This is a cardinal requirement. Be honest with yourself and with all with whom you deal. Be truthful, avoid fraud, exaggeration, or deceit; be frank, genuine, and trustworthy. Never make promises that cannot be kept. To maintain your self-respect and the respect of others:

Don't lie or distort the truth about anything pertaining to your work.
Don't misrepresent yourself.
Don't make misleading statements.
Don't be a party to fraudulent statements or practices.

Don't evade answering questions or statements for supposed self-protection.

Don't practice deceit upon yourself or others.

Don't exaggerate your efforts or intentions.

Don't make promises or give your word to someone and then fail to fulfill it.

Your honesty and integrity mean much in your achievements. Be honest with time-study work; there is nothing about it to conceal or misrepresent.

2. Personality.—Many people have wonderful personalities. Such personalities may be inherent or may have been acquired and then developed to the proper degree.

A person with a good personality is first of all a natural character, without self-consciousness, and whose dignity is not too severe. He probably has earned his distinction by unconsciously having one or more of the 24 items in the foregoing list of qualities.

Personalities can be improved. One very good method of improvement is to become a student of human nature. Your field can be the stage, church, your parents and relatives, your friends, or other persons around you who possess the individualities worth adopting.

Study each person separately to learn and emulate this priceless asset. Study them for friendliness, cheerfulness, open-mindedness, fairness, imagination, even temper, optimism, patience, good listening or sympathetic ability, originality, reliability, and trustworthiness; study their habits, their hobbies, their attitude toward mankind—in short, all those attributes that are a part of the individual you are analyzing.

When you have decided to develop desirable traits, make them become natural traits as quickly as possible. Practice until they become so deeply rooted that you are not conscious of their existence.

3. Imagination.—The T.S.M. should have the power of imagination. Frequently, he is called on to study jobs which are foreign to any that he has previously handled. In the absence of experience or ability on that type of job, he must trust to his imagination as the first step of his approach. The worker may be dealing in the official way with elements which seem strange to the T.S.M. and which necessitate advice for their proper understanding.

Imagination is a process of thought. A mental image is created from which thought originates. This creation of the mind leads to reason.

On jobs unfamiliar to the T.S.M., he must not try to hide his ignorance but should ask intelligent questions of the worker, executives, or of anyone in whom confidence can be reposed. Thus, when the T.S.M. learns how and why things are done, his imagination and reason can lead to mastery of the creative aspects of the job.

Our interpretation of the word imagination is confined solely to the prerequisites for an accurate appraisal of the task in question. It has no connection with so-called flights of fancy or air castles that are popular conceptions of the word.

4. Sense of Fairness.—Referees and judges of all things, legal and otherwise, must have a sense of fairness. Since a T.S.M. is an appointed judge, he too must have this quality to a marked degree. He must be impartial and just and not swayed by undue suspicions. He is a neutral agent whose function is to interpret with absolute integrity the impartial facts and figures of a job or industry to both employers and employees. He must be free from all bias or prejudice.

If a T.S.M. is fair-minded and can so establish himself, he will secure the trust of his superiors and 95 per cent of the workers will rely on him and play ball fairly. The other 5 per cent may not; their distrust, craftiness, or general attitude toward him and the plant as a whole may make it almost impossible for the T.S.M. to be recognized in their minds as an equitable medium in whom they may place their trust. To this small percentage of workers the T.S.M. should explain that he is endeavoring to play ball fairly in spite of the handicaps they are attempting to create toward his efforts. His sense of fairness is called on in a positive way to keep down his prejudices toward this group of unwilling men.

A T.S.M. should not prate continually to each worker that he will give him a fair deal. His time studies will reflect that fact. Actions speak louder than words.

5. Open-mindedness.—If a person has a sense of fairness, he is usually open-minded. He welcomes and encourages suggestions and is always open to conviction. Any plan or idea submitted to him is given attention and consideration. His

mental attitude permits him to consider in an unbiased frame of mind any information or data regardless of their source.

The T.S.M. should avoid having it said of him, "You can't tell that fellow anything, because nobody's ideas are as good as his own."

6. Power of Sympathy.—Unimaginative people cannot be sympathetic. In order to sympathize truly with another in misfortune or suffering of any kind, one must, from reasoning or experience, be able to place himself in similar circumstances.

A T.S.M. must have a fellow feeling for the man with whom he is dealing. Since he is associated with labor, he should give serious thought to all kinds of problems related to it, real and imaginary. Workers will come to him with complaints or tales of woe that might seem trivial to anyone but the person who makes them. Thus, his power of understanding and his ability to place himself in the worker's situation becomes a big asset to the T.S.M.

To treat grievances lightly or to ignore them simply because you are uninterested or too busy may lead to trouble. It's a part of your job to listen to them sympathetically and adjust them to the satisfaction of all concerned. It is well to remember that regardless of the nature of the complaint, the mental attitude of the worker is undoubtedly sincere. If he is slighted, he then labors under a misapprehension that the T.S.M. is unfair and cannot have the proper frame of mind toward him or his work.

7. Tact.—Our use of this word naturally calls to mind the sensitive nature of the problem that is always involved in rendering critical judgment concerning anyone's work or conduct. Tact implies a delicate mental perception of what is fit, graceful, or considerate under such circumstances. It is a peculiar ability to deal effectively with others without giving offense.

A good T.S.M. tactfully anticipates and quietly avoids friction in the pursuit of his duties. Criticism is a personal matter to the one who receives it. It must, therefore, be just and constructive and should be rendered with a considerate appreciation of the other fellow's feelings.

The T.S.M. many times discovers that an operation or a method is not conducive to best results. It often happens that the operation or method is, nevertheless, the "brain child" of someone who believes its merits are unassailable. To alter that

method without antagonizing the persons involved is a test of the time-study man's tactfulness. For instance, never say, "That operation is terrible." It might be the height of perfection to the originator. It is much better to say, "I like this operation very much and whoever originated it deserves credit, but even so, I should like to suggest a slight change to see whether the watch shows a little time saved."

If you irritate an operator or incur the wrath of the foreman, you should ask yourself, "What did I do that was wrong?" And, having found the answer, you should make a mental note of that occasion and thereafter avoid a repetition of the error.

8. Resourcefulness.—Operations are completed by using what might be called "official movements." These movements, upon analysis, may not always prove to be the best. For example, in textile mills a great number of movements are traditional; they were done that way one hundred years ago and, until recently, no one has given serious thought and study to their improvement. Many an executive confines himself so closely to the routine demands of his job that he fails to get a true perspective of its maximum possibilities.

The T.S.M. is not limited or dulled by being confined too long to one specific job or operation. The broad scope of his work tends to develop originality, and this originality or initiative can often devise schemes or suggest ideas that are novel and effective and which will bring new life and vigor to old-fashioned or merely traditional operations and methods. The T.S.M. witnesses movements that appear slow, awkward, or laborious, and by drawing upon his wide observation and trained intelligence, he is able to bring them quickly up to date.

Operators do not always respond in a wholehearted way at the time they are being time studied. Resourcefulness will prove a material aid in obtaining their cooperation.

9. Reliability.—This quality in a person denotes that he is dependable, is worthy of trust and reliance, and is one in whom people may place their confidence. A reliable person is practical, does not employ hit-or-miss tactics, and is capable of applying his knowledge to useful ends.

Since time-study work at first appears mysterious to the average worker, the T.S.M. must earn the respect of all—not only by his honesty and sense of fairness, but by something

further, his reliability. To trust him, they must have confidence in his statements, his analysis, and actions. Therefore, it behooves a T.S.M. to make only clean-cut statements that are free from guesswork. He should quote facts and not theories and always stand ready to back up his facts by proof.

In our use of the word reliable, it is not to be confused with honesty; a man may be quite honest and yet have no reliance placed in his statements or actions because he is found to be without adequate facts or judgment.

10. Self-control.—Very few people can go through life without losing their tempers occasionally. It is hard to exercise self-restraint continually. Some people are burdened with temperaments and dispositions of such hair-trigger nature that their natural inclinations cause them to become easily irritated, and when composure is gone, fiery temper prevails. Always keep in mind that an even temper is a priceless jewel to the T.S.M.

Stockholders cannot afford the kind of man who gets angry and loses his grip on his job. That handicap may outweigh all other virtues and either cause him to lose his job or retard his promotion.

A T.S.M. should make every effort to be master of himself. He should cultivate self-control to the point where he becomes so "thick-skinned" that if he does become angry at times, at least it doesn't show because of his superb control.

Operators can always find the weakness in a time-study man's armor. If that weakness is found to be his quick temper, they will often capitalize on it. An actual occurrence will serve to illustrate this danger. An operator was being studied on a job upon which he was engaged month after month, and for which a piecework rate was to be granted. He gave the T.S.M. an excellent demonstration and an accurate study was secured. As the T.S.M. was preparing to leave, the operator deliberately provoked him and hot words were exchanged which caused the foreman to interfere. Later, the operator obtained a better piecework price for his operation by contending that the T.S.M. was too angry to do justice to his work and consequently, in his prejudice, was treating the operator unfairly. This was a costly error to the company, but insured an easily made day's pay for the shrewd workman.

11. Energy.—An effectual productive activity is expected of all labor. In fact, activity is one of the important aims of industry. This aim is understood by the workers. Particularly because of his responsibility for inspiring and securing maximum results from others, a T.S.M. should be vigorous in all his efforts and devote himself with untiring enthusiasm to the carrying out of every phase of his own work.

As the T.S.M. is developing a seasoned ability, he will labor much harder to arrive at his conclusions than he will later on. At first, his caution, in order to sustain his judgment, will consume more time than will be required after experience is gained. His later efforts will naturally be more effective. Energy without accomplishment is so much wasted steam and should always be avoided.

A bald-headed barber cannot successfully recommend hair-restoring liquids to discerning customers; neither can a lazy T.S.M. inspire the hearty cooperation of labor.

12. Proper Conduct.—Ownership of the qualities thus far delineated will go far in equipping the T.S.M. with the properties necessary for his success in personal relations with labor.

Where a T.S.M. is recruited from the ranks of his fellows, he must exercise especially good judgment and marked self-restraint if he is to maintain their respect. Any noticeable change in his behavior will very likely be misinterpreted. This raises some delicate problems as to just how he should conduct himself.

One method suggests the T.S.M. gradually work away from the possible entanglements of former associations. This may not be necessary as a general policy but most assuredly is desirable where an associate presumes on friendship and requests favors so irregular that they cannot be honestly granted. A true friend does not expect nor demand undue favors. One test of his friendship is his reaction to your promotion and progress. His attitude, if changed, should make a definite register upon you and thereby measure the true worth of his friendship.

If careful thought suggests a radical departure from old mental attitudes and habits on your part, they should be made as quickly as possible. We know of many successful time-study men who were selected from factory departments and who have maintained excellent contact with their shopmates before and after

starting time-study work. These time-study men were required to make but few changes in their characteristics and, consequently, few friendships were sacrificed.

On the other hand, many time-study men, in order to become successful, were obliged to adjust their ideas of conduct. These changes occasionally resulted in strained relations with a few of their acquaintances.

The proper adjustment of conduct for securing best results in time-study work is just as necessary as in hundreds of other enterprises, but no more so.

In dealing with operators who are strangers to the T.S.M., contact will be easier because conduct can be strictly professional and unhampered by the liabilities accruing from time-studying an intimate friend.

In a few words, the conduct of the T.S.M. should be on a friendly man-to-man basis, embracing cheerfulness, tempered by the right percentage of sober-mindedness, and with the proper diplomacy to earn and keep the worker's respect.

13. Self-confidence.—Belief in yourself is not conceit. If you have a secure and sincere feeling of confidence regarding your ability and can trust your judgment without fear of failure, you have self-confidence. This confidence should not be a false feeling of security, nor should it be filled with disturbing doubts or shaken by occasional errors; it must be the real thing and fully able to survive the disappointments of human error.

Self-confidence is not a feeling of self-importance. It has no relation to impudence or boldness. Moreover, it does not close your mind to the value of cooperation and the benefits of council to be obtained from people around you. Much has been written in newspaper articles and books about "inferiority complex"—which is only another word for the lack of self-confidence.

Many men lose faith in themselves when called upon to discuss details of their work with high officials in manufacturing plants or when called upon to speak before a group of people. Their coolness and positiveness desert them and embarrassment takes the place of calmness. They cannot find words to express themselves.

This suggests a quality required by the T.S.M. He should have clarity of expression and never be at a loss for words to clothe his thoughts. Contact with people will do much toward

developing this ability. We recommend that the reader broaden his vocabulary.

This can be accomplished in several ways. One way is to read the editorials of clever writers in newspapers and to select from them words that are suitable for your use. Good editorials are usually brief but cover the subject by the use of adequate words. These words are not "jaw-breakers" because clever writers do not resort to the use of such words. The student should select only such words or expressions as help him in his work. He should adjust himself to the caliber of the person to whom he is talking. If that person is uneducated, simple words should be used for perfect understanding. In talking to highly intelligent people, the conversation might call for the use of precise English with a convincing choice of words. A double negative or a badly used or mispronounced word can easily provoke amusement on the part of the listener and thereby destroy the force of whatever statement is being made.

One of our engineering friends recently advised us that he has adopted a practice of acquiring a new word every day. Before retiring, he selects a new word from his dictionary and writes the word on a slip of paper, with its pronunciation and meaning, and then pins the slip over the bathroom mirror. He uses the particular word in various sentences before dropping off to sleep. The next morning while he is shaving, the word is again before him and thus becomes committed to memory.

14. Cooperation.—This means teamwork, acting or operating jointly with others. What you expect from life will be in a direct ratio to what you contribute to it; you cannot take out more than you put in.

In most spheres of action, no man can do it all. He must expect and, in return, give assistance. To secure time-study data that can be compiled without complication, each worker should be honest in his attitude and performance. In return for this assistance, he expects a reciprocal cooperation from the T.S.M. in the form of an accurate analysis and equitable time allowance.

Without cooperation from labor, time-study data become an involved story. A most important part of the contact that a T.S.M. must have lies in his ability to secure the wholehearted cooperation from the operators he is studying. This can be done by a frank discussion of the methods used in time study.

Among these methods, the rating principle (outlined in Chap. IV) should be painstakingly explained. Each worker should be told that the watch is stopped whenever any foreign movements by the worker are witnessed.

Since time study is a benefit to labor, it can be "sold" on that basis. The resulting cooperation should be spontaneous. If it is not, something is wrong with the contact of the T.S.M.

15. Sense of Responsibility.—You, as a T.S.M., occupy a prominent station in industry. Officials in factories are beginning to recognize this fact more deeply and are in turn demanding well-balanced men to carry on this vital work.

Correct time study is a means of settling many things. Chief among them is costs. It reveals the reasons why costs are either high or low. Selling prices are established from costs and the industries selling to the great mass of people must give value per dollar. The T.S.M. does more than any other person in the plant in setting up values.

He is, as previously stated, a connecting link between the employer and the employee. This is a further responsibility. He must do his job well.

16. Observation.—First of all, concentration is necessary. Observation is a result of concentration. The first step in time-study work is to cultivate the faculty of seeing things—to witness all proper details and itemize them in writing. All work is composed of details that must be observed; thus, it is imperative that the T.S.M. be an excellent observer.

Details cannot be observed unless a continuous effort is made to rivet one's attention to the task. Whenever the mind wanders away from any subject and attention is lost, then that attention must be brought back each time. One reason for inability to concentrate is mental or physical fatigue. In such circumstances, the T.S.M. should change his immediate work until he has secured rest and the fatigue is overcome. Some people believe they can concentrate much better during certain parts of the day and take advantage of those periods for any unusual mental application.

Real accomplishment is based on intelligent observation. Some people see with "unseeing eyes." Ask any group of persons to describe the details of an accident and many versions will be given. To grasp with mental alertness the external

things connected with time study and reduce them to accurate conception is a vital part of the profession on which you have embarked. Train yourself in the complete mastery of this function and you will be handsomely rewarded.

17. Analysis.—To arrive at analysis, a process of investigation is first met. All details must be investigated and subjected to patient inquiry. This inquiry may take the form of council with all concerned with the job, or the consideration of similar methods or ideas in use elsewhere in the plant which might be units of measure or comparison.

An analysis is a "breakdown" of anything connected with the task into its constituent parts or elements, an examination of component parts separately or in their relation to the whole. Each operation, when broken up into elements, is then ready for time measurements. Since this book deals with analysis, much more will be said about it as you progress.

18. Judgment.—The ability to exercise sound judgment demands many mental traits. Judgment can always be questioned unless it is based on a complete knowledge of the facts. Since mechanical laws are definite and are subject to proof where there is an adequately prepared mind, opinions can therefore be positively stated.

We have previously said, "The effectiveness of labor is determined by the personal characteristics of the worker. It includes such things as 'temperament, skill, effort, intelligence, experience, physical strength, endurance, and resourcefulness.' " A contemplation of any of these qualities immediately indicates the present lack of laws or facts pertaining to them. Consequently, judgment alone determines the effectiveness of any of these eight qualities. A discriminating T.S.M. whose judgment is mature will have but few difficulties in setting up values for them. This maturity will come from a general education in time-study principles and common sense. Added experience will strengthen his judgment and enable him to weigh facts or theories, season his art of comparison, and permit him to commit himself definitely to formulated opinions. A T.S.M. should never base his opinions on impulse, snap judgment, or guesswork.

19. Accuracy.—A mechanic using micrometers has prescribed limits of plus or minus so many thousandths of an inch for his work. The T.S.M. should also be restricted to extreme limits

of error. His limits should be no more than plus or minus 5 per cent, *i.e.*, a piecework price or time allowance that is either 5 per cent loose or 5 per cent tight.

Accuracy results from

Correct observation.
Correct analysis (includes all proper allowances).
Correct judgment.
Correct reading of watch.
Correct figuration of data.

All time studies should be thoroughly checked in the time-study department and actually tried out on the operator for a short period before official release to the plant.

A disconcerting situation arises, for example, where the T.S.M. studies some particular job and finds that the worker should produce a great many more pieces per day over his present output. After much discussion, the data are finally accepted and an honest effort is made to meet the new production specified. A thorough trial is given, without successful results, and then an error is discovered which shows the impossibility of the demands. Although the error might have been such an obvious thing as a misplaced decimal point, many workers would lose faith in the T.S.M. and feel that all other studies were subject to correction.

A "spot check"[1] on the study would undoubtedly have revealed the error beforehand and saved the hard-earned prestige of the T.S.M.

Errors in time studies sometimes react in a peculiar manner on the workers. If a study is too tight, some of the workers are prone to feel that the T.S.M. is a stockholder and is trying to pay high dividends on that study. Then again, if the error occurs on the loose side, there is a tendency to view that job as an index, with the same latitude wanted in all other studies.

Any mistakes that are traced to inaccurate figuration should be corrected after a full explanation is made to the operators concerned. Studies that are too tight (not caused by errors in figuration) should be adjusted immediately. Studies that are too loose (aside from errors in figuration) should remain in effect without change. This latter rule although hard on the T.S.M. is one of the successful plant policies that preserves morale.

[1] The spot-check principle is explained in Chap. XVI.

20. Planning Ability.—The duties of a T.S.M. do not cease when he has applied his studies to a job. Changes may occur when the operators, in their zeal to produce, may impair quality; when other operators feel that a recheck of their work is desirable, etc.

The T.S.M. should plan his time so that a portion of the day can be devoted to the following up of studies in use. His schedule of time should permit of his interviewing foremen, inspectors, operators, or others on whom the continued success of his studies depends. He should allot sufficient time to look over the daily shop or office records that are the barometers of productive conditions and to investigate any items that are off-color.

On new work, studies should first be made on the most important operations from which the best returns can be secured. If time-study procedure is new in the plant, then the selection of the job should have careful consideration. The workers should be willing, the foremen and others entirely sympathetic, and the particular operation should be of such character as to yield quick results that are pleasing to the workers and to plant officials. A good application of time study does more in the way of forceful advertising than any other medium.

The classifying of new work on the program of the T.S.M. is a part of systematic planning. The compilation of special data can be started long in advance of the study to be taken. These data may be inspection reports, tool breakage, waste, percentage of counts, or many other things that should be recognized and that have a bearing on the proposed study. The foremen or their clerks can assist in the building up of incidental data and thus save many hours.

Just as a good executive always has the next job ready, so should the T.S.M. know definitely from his schedule what his next step is to be.

21. Power of Instruction.—A complete understanding of time-study principles does not necessarily imply the ability to impart this knowledge to others. Many teachers in schools have brilliant minds but, unfortunately, cannot convey their learning to their classes.

For the sake of comparison, we shall assume that the students making up the classes in colleges have all passed through a series

of more or less standardized methods of instruction and that their successful passing of tests has yielded them credits which entitle them to the status of their present levels. If this is true, then the teacher is dealing with individuals who fall into rather definite limits of classification. And although his teachings are a great deal more complex, nevertheless he is instilling that knowledge into minds that have been tested and graded before being admitted to the classroom of the instructor. Even with this unity of mind, powers of reasoning and other mental equipment which should respond to further treatment will not flourish unless the seeds of knowledge are implanted by one who not only is wise but who can make his precepts understood.

The T.S.M. has comparatively simple data to impart. His classroom audience, however, ranges from the low to the high extremities of intelligence. His story must be told in the most effective way for penetration and understanding. This story, therefore, must take the clearest form of word pictures to some workers, whereas other listeners will comprehend the outline of the principles if treated differently.

To test the effectiveness of his instruction, the T.S.M. should request his listener to go over with him the various points discussed and thus learn of any doubts or misunderstandings that can be dispelled or clarified.

22. Optimism.—Infinite patience becomes a strong link in the chain of qualities thus far covered, the product of which should endow the T.S.M. with an optimism to back up his time-study work.

At times, the force of dissenting opinions against the fairness or accuracy of some given standard may cause him to waver in his resolutions and the resultant weakening on his part often creates an opening wedge of pressure that may alter his views and end with the granting of a substantial increase in time allowance. Later, if the original standard is found to be correct, the T.S.M. sometimes exposes himself to a countercriticism from the same sources because of his apparent willingness to change the standard, even though pressure had been exerted against him. This ironic situation should be met by his enduring patience and determination to stick by his guns when he is sure he is right.

In a New England cotton mill, standards were established on spinners and the doffers who serviced the frames. When the

standards were applied, all operators and officials felt that the newly specified output could not be met. These standards for the spinning and doffing were periodically checked by request, and all-day observations would each time prove their correctness. On days between checks, the production would drop back and the waste factor increase. For nearly one year a constant criticism was leveled against the T.S.M. whose accuracy was beyond assault and who would not change the standards unless an error in them could be found. At last some changes were made in the organization and the production soon reached the prescribed amount with low waste factors. The tenacity of the T.S.M. saved the mill thousands of dollars each month and, as a result, his optimism was rarely questioned afterward.

23. Salesmanship.—Selling an article that has proved its reliability and that is well advertised and well esteemed is not such a big task. The buyers want it and are satisfied with its merits and become endorsers of it. The so-called sales resistance to such an article is negligible.

Selling a strange article in a new territory becomes a different task. The intended purchaser will want to know something about its value, its durability, the integrity of the persons in the firm promoting the article, the firm's attitude toward its customers, its policy regarding adjustment of complaints, the continued satisfaction after purchasing, etc.

The salesman selling the article must first of all believe in it himself. He does not resort to the singsong style of talk memorized from a sales manual and delivered in machine-gun fashion. Instead, the good salesman will tell a complete, honest, straightforward story in language that can be readily understood. He will emphasize the unusual points of appeal and truthfully answer any questions, thereby clearing up any doubts in the mind of the purchaser.

The fly-by-night street-corner salesman selling trinkets of dubious value resorts to tricky practices. From the sheer noise of his sales talk, use of theatrical gestures, and vague references to guarantees, the trinkets are finally sold to spellbound buyers who later discover they have been stung and return to the spot, only to find the salesman has vanished into thin air.

The T.S.M. does not resort to trick practices. He is selling an article to labor. This article is a means of securing their

daily bread and is therefore an important article. He must first of all sell himself, then sell his merchandise and keep it sold. This can be successfully accomplished through proper contact.

24. Leadership.—Confidence is the first step in leadership. Being called upon to judge human nature, a good T.S.M. knows each worker, has a keen interest in him and his problems, is anxious for the worker's success, and, as a result, becomes "a friend in need." This feeling of friendliness toward the T.S.M. may not manifest itself at first, but in the process of time, all fair-minded men will come to him with business and personal problems, knowing that sympathetic attention will be given and that any promises made by the T.S.M. will be carried out to the best of his ability.

The T.S.M. has no authority to hire and fire labor. He has no appointed commission to control the deportment of any worker. The discipline he obtains results from his contact. The workers all know he is a neutral agent so far as their conduct is involved, yet they will subscribe to his leadership if he knows how to handle them. His assistance and encouragement stimulate a spirit of loyalty and pride of workmanship which become a part of an enthusiastic desire to meet the daily task set before them.

The type of leadership necessary on a given job varies as the nature of the worker varies; not all people react to the same treatment. Plant officials occasionally fail to appreciate this logic. In their rush to meet the demands of costs, rigid inspection, and shipping schedules, they overlook the most valuable accessory—the handling of men.

High wages, modern equipment, high pressure, and other things associated with industrial life will fail of their purpose without leadership that results in successfully appraising and handling each worker. The success stories of thousands of big men are built around the rewards accruing from leadership. History is full of noteworthy men who possessed at least one characteristic—the ability to lead men into action.

The qualities treated in this chapter are shown in the following table. A list was prepared of the names of the foremen and other higher executives, together with the names of time-study men, with whom the author has been associated in many industrial plants of various kinds from Massachusetts to California.

The percentages shown for each quality are group averages. Each of the 24 qualities, according to judgment, were given as either a negative or positive point of credit to every one of the names in the list. If a person possessed a given quality to a marked degree, one point for it was credited in his favor. If he suffered a decided lack of any quality, one equal point was made against him. All gradings were made after acquaintanceship sufficient to permit an intelligent analysis.

Item	Quality	Average of T.S.M., per cent		Average of executives, per cent	
		Positive	Negative	Positive	Negative
1	Honesty	84	16	72	28
2	Personality	73	27	58	42
3	Imagination	66	34	53	47
4	Sense of fairness	76	24	57	43
5	Open-mindedness	72	28	55	45
6	Power of sympathy	67	33	52	48
7	Tact	71	29	48	52
8	Resourcefulness	66	34	52	48
9	Reliability	74	26	67	33
10	Self-control	81	19	69	31
11	Energy	63	37	56	44
12	Proper conduct	69	31	64	36
13	Self-confidence	67	33	72	28
14	Cooperation	77	23	51	49
15	Sense of responsibility	83	17	69	31
16	Observation	82	18	63	37
17	Analysis	76	24	61	39
18	Judgment	73	27	54	46
19	Accuracy	71	29	65	35
20	Planning ability	61	39	51	49
21	Power of instruction	64	36	54	46
22	Optimism	68	32	74	26
23	Salesmanship	67	33	52	48
24	Leadership	59	41	49	51

The data from the foregoing table are shown on page 28 plotted in the form of a circular Capacity Chart. It is interesting to note that with the exceptions of items 13 and 22, the time-study men show higher percentages than the executives. In explanation of this, it may be stated that since many of the

time-study men were only partially trained, the final average percentages for the qualities of self-confidence and optimism could not be expected to be as high as those of the executives.

A careful examination of the Capacity Chart will forcefully indicate why modern time-study methods were necessary in the plants from which these data were taken. Executives and time-study men all along the line improved greatly by using the chart's data as a guide for self improvement. In many of the plants

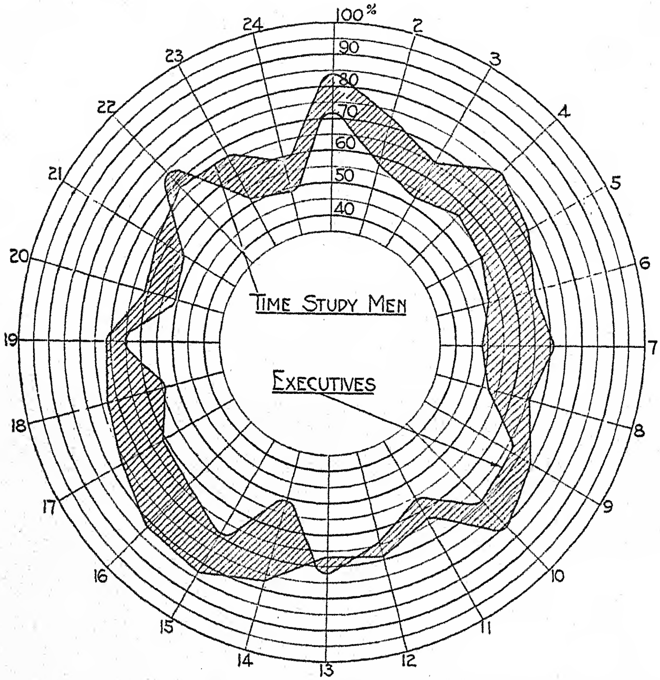

ILLUSTRATION A.—Capacity Chart showing a comparison of 24 qualities to be improved, if possible, to reach more nearly the 100 per cent line.

there were excellent executives and time-study men who were given very high general ratings, but, of course, there were poor ones who contributed to the prevailing average.

Since we are discussing average cases, you as an average reader and T.S.M. will readily appreciate the necessity for self-improvement. Certain qualities can be developed faster than others. They are grouped as follows:

(a) Easiest to acquire............	Items 1, 11, 14, 15, and 22
(b) Next hardest to acquire.......	Items 4, 5, 6, 9, 13, 16, 20, and 21
(c) Hardest to acquire............	Items 2, 3, 7, 8, 10, 12, 17, 18, 19, 23, and 24

It has not been our attempt thoroughly to treat in this chapter each of the qualities we feel are necessary for your 80% – 20% make-up. The few pages devoted to them are only our brief interpretations. You should cultivate them in their fullest sense by all available means for your ultimate good.

Questions

1. In the early part of the chapter it was stated that the effectiveness of the individual worker is determined by his personal characteristics. What are those eight characteristics?

2. Are the data found by time-study analysis confidential and confined only to the use of the T.S.M. and plant officials?

3. If, as a result of lack of tact, you have irritated an operator or incurred the wrath of the foreman, what attitude should you assume?

4. Item 10 on the Capacity Chart on page 28, shows only 12 per cent difference between the T.S.M. and the executive. Explain briefly why the quality of self-control on the part of the T.S.M. should be developed until it reaches the 100 per cent circle on the chart.

5. (a) Within what recommended limits of time-study accuracy should the work of the T.S.M. be confined? (b) Name five items pertaining to time-study work that contribute to accuracy.

Answers to Questions

1. The eight personal characteristics that determine the effectiveness of the individual worker are

Temperament.
Skill.
Effort.
Intelligence.
Experience.
Physical strength.
Endurance.
Resourcefulness.

2. There is nothing regarding time study to be treated as confidential data. Page 7 in this chapter states that it becomes a set of instructions used by the workers and executives in the plant. Any air of mystery, uncertainty, or prejudice that might be associated with time-study findings or conclusions, should be dispelled by frank discussions of its benefits to all concerned.

3. When mentally analyzing the details of an unpleasant conversation, the T.S.M. should assume that his lack of tact was the main contributing

factor causing the irritation regardless of the other person's temperament. Thus, placing the blame upon himself, he is better able to correct this weakness and avoid recurrences of unpleasant situations.

4. According to the Capacity Chart on page 28, the average executive is only 69 per cent perfect in his ability to maintain his self-control. Therefore, his 31 per cent liability is easily provoked by a T.S.M. who cannot exhibit a calm composure. If the T.S.M. can be master of himself at all times and cultivates self-control to the 100 per cent line on the chart, his job will become easier, and satisfactory time-study results will be secured without the deterring influences caused by loss of temper.

5. (*a*) It is recommended that an extreme error of 5 per cent be established for the accuracy of time-study work. (*b*) The five items pertaining to time-study work that contribute to accuracy are

Correct observation.
Correct analysis.
Correct judgment.
Correct reading of watch.
Correct figuration of data.

Chapter II

There are at least two fundamental methods used to time operations by means of the stop watch. One is called the continuous method and the other the snap-back method. Both methods are dealt with in the text, but based on the judgment of many engineers, the snap-back method is recommended for best results.

As stated in the text, if the true theory of the continuous method is observed, the watch must be kept running during the timing of the operator regardless of the many possible foreign items encountered during the time study. These foreign items are recognized by means of marginal comments, codes, or other notations to indicate that they are to be later removed from consideration. Thus, the mental concentration that the T.S.M. should apply to the job under observation is disturbed first when he has to set up the nonessential items and then when again he has to remove them immediately.

The best method of timing any operation is that which allows one's attention to be devoted almost entirely to the task being analyzed and time-measured. It is believed the snap-back method requires less time to record all essential data because the nonessentials are not posted and thus the T.S.M. can devote more attention to the job being studied and less to his paper work. The snap-back method allows the stopping of the watch for nonessentials and thus the timings for them are not recorded.

CHAPTER II

THE STOP WATCH

The time-measuring instrument recommended for your time-study work is the standard type of watch in general use in the United States.

It is a nickel-plated, seven-jeweled, decimally-marked dial stop watch and contains one large and one small hand. Pressing the stem-set returns both hands to zero. On the edge of the watch case is a starting and stopping lever operated by a lateral movement of the left thumb. This lever can be operated as many times as necessary in the course of time-study observations to start or stop the watch and does not disturb the accumulating readings being registered on the watch dial. When the particular reading has been noted, the watch hands are returned to zero by depressing the stem-set with the left thumb. See illustration.

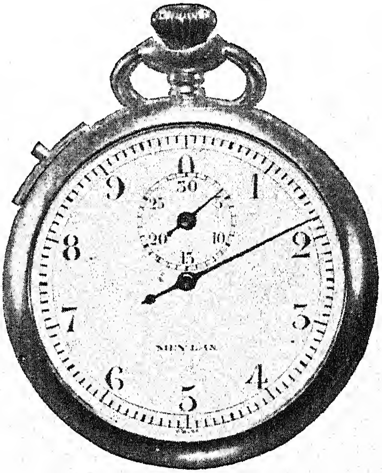

ILLUSTRATION B.—The type of stop watch recommended.

The T.S.M. will soon learn that when he returns the hands, he can hold them at zero by keeping the stem-set depressed with his thumb. We do not favor this practice, because it will be found that as the watch becomes worn from use, the hands will not always start off when the stem-set is released. It is much better to remove the thumb quickly and if you are not ready for the next reading, depress the stem again when you are ready. Of course, if you are interrupted in your work, the slide should be used to stop the watch.

As stated, the watch has two hands. The large hand makes one revolution in 1 min. and the small hand makes one revolution in 30 min. In reading the watch for times longer than 1 min., the T.S.M. first reads the small hand, which tells the number to be written at the left of the decimal point. The figure indicated by the large hand is the decimal fraction of the minute to be recorded at the right of the decimal point. For example, if the small hand reads "3" and the large hand has turned halfway in its revolution, the time is recorded as "3.5 min." and not "3½ min." The oral expression of the time is, "Three and five-tenths minutes," "twelve and seventy-eight hundredths," etc.

Most factories use decimal watches instead of second-reading ones, because the minute is split into finer divisions. Also, in computations, the times can be multiplied, divided, added, or subtracted much easier. *Example:* 5 min. 18 sec. minus 3 min. 36 sec. = 1 min. 42 sec. This requires more figuration than the same times expressed in decimals, *i.e.*, 5.3 min. minus 3.6 min. = 1.7 min., which is found by direct subtraction.

Time allowances should be expressed in minutes or decimal fractions thereof. When a decimal watch is used, the final time allowance is read direct from the sum of the elements, whereas if a second-reading watch is used, a final conversion to minutes is necessary.

Seconds can be converted to decimals by dividing the time in seconds by 60. *Example:* 72 sec. ÷ 60 = 1.2 min. Expressed in a formula, it becomes

$$\frac{\text{Seconds}}{60} = \text{decimal minutes} = \frac{72}{60} = 1.2 \text{ min.}$$

Or

$$\text{Decimal minutes} \times 60 = \text{seconds}$$

In reading the stop watch, the T.S.M. should not attempt to interpret the time by mentally quoting the exact time before returning the hands to zero. Instead, he should note the *exact position* of the hands and immediately return them to zero. Then as the hands are again starting forward, he should translate the position into time and record the reading without watch delays.

Operations are comprised of few or many suboperations which are called "elements." Each element is to be timed and a proper time value set up for it after analysis. The sum of the elements, together with other proper time allowances added, becomes the cycle. This cycle, expressed in minutes, is the length of time allowed to complete one piece, gallon, yard, pound, hank, skein, square foot, or any other unit by which payment of the work is to be made.

Cycles are timed with the regulation stop watch by at least two fundamental methods:

1. The continuous method.
2. The snap-back method.

Although we shall discuss the continuous method, we do not favor its use for general practice in time-study work.

The continuous method means that the watch must be kept running continuously throughout the whole time the T.S.M. is studying any task. During the time that the watch is running, the T.S.M. notes the dial reading when the first element is completed and records it and, likewise, the accumulated times for the other elements in the cycle. With the watch still running, he posts the time data for anything that occurs in the operation whether it has a direct bearing on the job or otherwise. Odd movements or delays that are foreign and will not be allowed in the final analysis may take place while the watch is in constant operation. Nevertheless, they must be noted by a definite registration on the Observation Sheet. Later, by a series of subtractions, they are thrown out. The starting and stopping slide on the watch-case rim becomes a little-used attachment if the true theory of the continuous method is faithfully followed during a period of study. Thus, the stop watch becomes equivalent to a clock-on-the-wall chronometer.

Some operations consist of many elements, and enough cycles must be timed to obtain data for proper analysis. On this type of operation, the Observation Sheet will contain many windows or spaces to receive the accumulated timings. In an effort to show his own efficiency, the T.S.M. will become so intent on filling in the windows, instead of watching the job in detail, that inefficiencies in the operation before him escape his notice. In case he is suddenly interrupted by the foreman or others, he

may go so far as to "fake in" certain time data that he has inadvertently missed. Thus, having his mind divided unequally between his own job and the one he is studying, he cannot do full justice to either.

Many operators do not perform their cycles exactly alike each time. Sometimes they transpose elements because it facilitates their work, or possibly on account of the fact that they are being timed. This leads to a complication in the continuous method since the sequence of movements is then different from the continuity plotted by the T.S.M. He must then reconcile the misplaced elements by means of footnotes, or by symbols to explain to himself and others why certain timings are not consistent.

In the midst of timing, foreign movements often creep into the study and, unless the T.S.M. is constantly alert, he will not recognize them until the watch hand has gone beyond the position of dial reading for which his pencil is poised, awaiting the watch reading to be posted in the next open window space on his Observation Sheet. By the time he is fully aware of a foreign element and has set up and recorded a code for it, the watch is so far ahead of him and so many windows are unfilled, the T.S.M. is likely to become nervous in his endeavor to catch up with the watch. He may believe it necessary from the standpoint of his own efficiency to reflect a solid block of postings to disarm possible criticism from his chief over the many open spaces or gaps on his Observation Sheet.

In the continuous method, the T.S.M. must, regardless of how long the operator is away from his job, record the periods of time the operator stopped to obtain a drink of water, or other stoppages for which a time limit taken from standardized data will be given. This unnecessary posting of data only clutters up or complicates the figuration of the net data to be analyzed. A time-study analysis that calls for a large percentage of increased production is often subject to a thorough scrutiny by the plant officials whose duties require them to sign and thereby endorse time allowances before official release. The fact that a study is given an unusual check by them may be taken as evidence of their doubts concerning the accuracy of the study. Should that study be filled with many items that were stricken out or radically adjusted, the attack of the officials on the validity of

the proposed time allowance might center around the items that were stricken out. These items, even though properly disposed of, might offer to doubting officials the most tangible means of increasing the time allowance on a comparatively simple operation which has been made complex by numerous notations and adjustments in the data to straighten out the "sleigh rides" the operator has interposed on his work in anticipation of his new output.

There is one condition under which the continuous method will find favor. It is the condition in which a skilled demonstrator is used to perform the operation. His speed and skill are such that they will not be questioned. The operation has previously been tuned up and the demonstrator completes it in the official way. This is an easy way of timing because no analysis is necessary. Also, the timing does not require the services of a trained T.S.M., for a cheaper type of man called an "observer" can be used.

After a thorough trial in many plants, the continuous method was discarded by the author and the snap-back method used for the basis of accurate timing.

The snap-back method means that the watch is returned to zero after the time is found for each element. Each element is treated as a separate story and analyzed and rated (the method of rating follows in Chap. IV) with the deliberation necessary for setting up time values. Not being required to concentrate so thoroughly on his paper work, the T.S.M. has greater opportunity to study the operation and to exercise his power of analysis and judgment in applying his ratings to the watch readings he has posted.

If foreign movements are noted, the watch is promptly stopped and no written explanation or reconciliation of times is necessary. If the operator stops to wipe off his forehead, the watch is stopped, because the rest factors covering such allowances will be granted when the study is ready for final figuration. In case the operator carelessly drops a wrench or performs movements that are not to be considered as official movements, the watch is stopped.

Often there are several operators lined up side by side, all of whom are doing the same operation. The T.S.M. may find that the first operator performs element *D* much easier than the other operators and so a better timing and rating can be

obtained from him. Perhaps the third man has less trouble with element *B* than the others, so a true value for it can be found more easily and equitably than the varying times found on the first man. The snap-back method allows for such deviation in timing.

If the factory whistle interrupts the study and the T.S.M. is delayed in getting back to the operation, he can begin timing the particular element in process and thereby obviate a waiting period until the operation starts off again on the first element. Some operators do not settle down to a smooth routine of work until a certain length of time has elapsed after the factory whistle summons them to work and consequently the watch is stopped a great deal, or the T.S.M. must wait until a few elements have been completed and the "warm-up" period is over.

Many times, particularly on a machine job, where the cycle is of considerable length and most of it is made up of actual machine time, the T.S.M. will time only a few of the machine elements, because they may not vary appreciably and but few readings are required to set up machine data. Therefore, instead of repeatedly timing complete cycles, he will spend his time profitably on other details of the operation; he will ask questions of the worker, have the worker repeat certain elements while waiting for the machine to finish its cut, repile castings, or do similar things that will confirm the data sought. Thus, the Observation Sheet might show many timings of some elements and very few of others so obvious that repeated timings do not reveal variations. The T.S.M. should not spend any more time than is absolutely necessary on a job; he should, however, spend enough time on any given task to secure adequate information for analysis.

On long cycles, over-all times can be used, but the watch must be returned to zero at the end of each cycle. The postings of the elemental times are the accumulated watch readings. Sometimes an additional stop watch can be used to advantage and started and stopped at will with the assurance that the first watch is picking up the over-all time. The additional watch may be employed to cover delays, foreign elements, etc., which are later deducted from the readings of the first watch before posting. Also, on long cycles over 30 min. in length, the stop

watch should be checked by a regular timepiece. In fact, on long cycles consisting of few elements, the regular timepiece can be used to record the accumulated times and the stop watch used in conjunction to modify any items that are subject to adjustment.

The over-all time method as outlined is sometimes demanded where only a very few pieces are available for study and may not be in production again for some time. The T.S.M. should not attempt over-all studies until he has taken many time studies and has acquired sufficient ability and experience to build standards on jobs of small quantities that do not permit many cycle timings.

On short cycles, the elements may be so brief that the T.S.M. is not able to look at the work, read the watch, record the data, and return his gaze to each element. In cases of this kind, the snap-back method will allow the study of every other element, and afterward, the picking up of the alternate ones.

Where cycles are less than .05 min. long, the T.S.M. does not break them up into elements, at least for observation purposes. If the operator is working at an unvarying rate of speed, the stop watch can be left running to pick up 10 cycles before returning the hands to zero; then clock 10 more, etc. Even though the cycle is short, its completion usually calls for a few elemental movements and although each is not timed, they should be listed for write-up purposes, notwithstanding the fact a group time for them is obtained.

The time lost in returning the watch hands to zero between elements by the snap-back method is so negligible that the loss is scarcely measurable. The exponents of continuous methods contend that time is lost in snapping the watch back each time, but say nothing about the blanket allowances they grant for fatigue and other factors that are more or less guessed at and which, at best, are so liberal that they transcend any accuracy that is stressed in one phase of time study and overlooked in other phases. We have seen the work of many untrained time-study men whose studies of various jobs showed extreme care in timing of elements to the point of specifying split seconds for some of the items, yet who blandly added on 25 per cent to 40 per cent to the data painstakingly arrived at, to take care of incidental allowances. These blanket allowances, when

added to carefully timed data, only destroy the accuracy the T.S.M. has shown in one spot.

The T.S.M. should never stand directly behind an operator while timing him. This practice causes the operator to become restless and suspicious of what is going on behind his back. The T.S.M. should stand alongside of the worker unless the latter's duties require his moving sidewise in the performance of his work. In that case, the T.S.M. should stand in front of him to keep from retarding the worker's movements.

The watch, if carried in the vest pocket, should remain there during all preliminary work and taken out only when the job is ready for timing. One courteous policy toward the operator is to inform him when the actual timing begins and also when the timing is ended.

Operators who are not used to stop watches are apt to imagine all sorts of things. Some will believe that the T.S.M. is continually operating his watch from his pants pocket and collecting information on all workers within his range of vision. The T.S.M. who allows this mistaken idea to prevail and walks into a department with his hands in his pockets will perhaps wonder why the workers nearest him are apprehensive and continually watching him. A thoughtful T.S.M. confines his gaze to the worker being timed.

Whenever a worker is being timed, the stop watch should be in plain sight. Some time-study men prefer the use of a special time-study board that has a metal holder attached to its upper end to contain the stop watch. The holder retains the watch securely and still allows ease of operation. Carrying the watch on this type of board allows it to remain in plain sight of both the T.S.M. and the workers.

One source of errors in time study is the misplacing of decimal points. The T.S.M. will draw off correct watch readings, but enter decimal points in wrong places. For example, if .75 min. is posted as 7.5 min., a loose standard will result. The T.S.M. should carefully examine his watch readings for misplaced decimal points.

The design and construction of stop watches are more delicate than regular pocket timepieces, so they should be handled with care to insure continued reliability. Your stop watch should be placed each night in a drawer at the factory and allowed to

run down. The next morning, it should be slowly rewound. Allowing your watch to run down overnight does two things: first, it preserves the life of the mainspring, and secondly, by being rewound each morning, your watch is sure to perform throughout the day. Nothing seems more exasperating to the T.S.M. when called upon to study a few remaining castings out of a lot which might not be in production again for several weeks than to learn that his watch was running down and consequently his time spent on the study was wasted.

Avoid laying your stop watch on a vibrating machine or on a bench where it is apt to jar off or be struck by a dropped tool. Should you accidentally drop your stop watch and it continues to run, it should be checked immediately with your regular timepiece for a suitable period to learn of any impairment to its accuracy.

Stop watches should be checked for accuracy with a reliable timepiece at least once a month. This can be done while you are completing the figuration of your time studies. To check, start the stop watch at some given time noted on the reliable timepiece and then write down the exact starting time. Since the stop watch completes one full cycle every 30 min., let it run a little past that length of time for a minimum test. If the T.S.M. feels qualified to adjust his watch, this can be done by opening the watch case at the rear and moving the regulator in the direction specified for Fast or Slow. Taking proper care of a stop watch will prolong its life many years. If your watch becomes broken, no one but an expert watch repairer should be allowed to handle it.

Questions

1. (*a*) State the formula for converting seconds to decimal minutes. (*b*) State the formula for converting decimal minutes to seconds.

2. Why is the use of decimal watches preferred to second-reading ones?

3. In reading a stop watch, should the T.S.M. actually quote to himself the exact time registered on the dial before returning the watch hands to zero?

4. When timing an operator, where should the T.S.M. stand for best results?

Problems

5. Convert 33 sec. to decimal minutes.

6. Convert 1.13 min. to seconds.

7. Convert 2 hr. 3 min. 12 sec. to decimal minutes.

8. Subtract 1 hr. 13 min. 20 sec. from 3 hr. 12 min. 19 sec.

9. Add 5 hr. 27 min. 21 sec. to 1 hr. 52.65 min. and show the sum in decimal minutes.

10. In timing a machine operation, the T.S.M. decided to use his regular watch to obtain the actual machine cycle; to use his stop watch to abstract the machine delay times. He observed the beginning of the cycle at 8:10:34 A.M., and its completion at 11:02:16 A.M. on the same morning. The accumulated unnecessary delays on his stop watch amounted to 13.7 min., which were subtracted from his regular watch readings. What was the allowed cycle in decimal minutes?

Answers to Questions

1. (*a*) Seconds/60 = decimal minutes.

(*b*) Decimal minutes × 60 = seconds.

2. Decimal watches reflect timings that can be multiplied, divided, added, or subtracted much easier than second-reading timings. This being true, there is less chance of error in figurations. Most time-study systems show the final time allowance in minutes, or decimal fractions thereof; consequently, the decimal watch yields direct time data that needs no conversion. Since the minute of a second-reading watch consists of 60/60ths, and a decimal watch, 100/100ths, it may be said that the latter offers a more accurate instrument for time measurements.

3. No. If the watch is stopped on, or allowed to continue beyond the reading observed, too much time will be lost in actually translating or making a mental statement of the time found. The T.S.M. should train himself to make a mental picture of the watch-hand positions and immediately return the hands to zero. While the hands are then starting foward on their next timing, the previous position can be leisurely interpreted into decimal minutes and posted without undue haste.

4. When timing an operator, the T.S.M. should preferably stand alongside of him. If this position is not possible, the job should be observed from the front of the operator, but never from the rear.

Answers to Problems

5. $^{33}/_{60}$ = .55 min.

6. 1.13 × 60 sec. = 67.8 sec.

7.
$$\begin{array}{rr} 3{,}600 \text{ sec.} \times 2 = & 7{,}200 \text{ sec.} \\ 60 \text{ sec.} \times 3 = & 180 \text{ sec.} \\ 12 \text{ sec.} = & \underline{12 \text{ sec.}} \\ & 7{,}392 \text{ sec.} \end{array} \qquad \frac{7{,}392}{60} = 123.2 \text{ min.}$$

8.
$$\begin{array}{rcl} 3 \text{ hr. } 12 \text{ min. } 19 \text{ sec.} & = & 2 \text{ hr. } 71 \text{ min. } 79 \text{ sec.} \\ 1 \text{ hr. } 13 \text{ min. } 20 \text{ sec.} & = & \underline{1 \text{ hr. } 13 \text{ min. } 20 \text{ sec.}} \\ & & 1 \text{ hr. } 58 \text{ min. } 59 \text{ sec.} \end{array}$$

9. $3{,}600 \times 5$ hr. $= 18{,}000$ sec.

$$\begin{array}{rcr} 60 \times 27 \text{ min.} & = & 1{,}620 \text{ sec.} \\ 21 \text{ sec.} & = & \underline{21} \text{ sec.} \\ & & 19{,}641 \end{array}$$

$$\frac{19{,}641}{60} = 327.35 \text{ min.}$$

$$60 \text{ min.} + 52.65 = \underline{112.65} \text{ min.}$$

$$440.00 \text{ min.}$$

10.

Ended	11th hr. 02 min. 16 sec.	=	10 hr. 61 min. 76 sec.
Started	8th hr. 10 min. 34 sec.	=	8 hr. 10 min. 34 sec.
	Difference	=	2 hr. 51 min. 42 sec.

$$\begin{array}{rcr} 3{,}600 \times 2 \text{ hr.} & = & 7{,}200 \text{ sec.} \\ 60 \times 51 \text{ min.} & = & 3{,}060 \text{ sec.} \\ 42 \text{ sec.} & = & \underline{42} \text{ sec.} \\ & & 10{,}302 \text{ total seconds difference} \end{array}$$

$$\frac{10{,}302}{60} = 171.7 \text{ decimal minutes}$$

$$\begin{array}{l} \underline{13.7} \text{ stop watch delay minutes} \\ 158.0 \text{ minutes allowed cycle} \end{array}$$

Chapter III

The ability to solve problems quickly on the slide rule is an art best learned by regular practice. Just as musical instruments are mastered by constant use, so is the slide-rule technique. An experienced musician does not literally interpret each note into terms of position on his instrument keys or strings. His musical score is played almost automatically. If he neglects to play or practice for a considerable period, he soon loses his proficiency in that art.

The slide rule may be compared to a musical instrument insofar as practice is concerned. It requires a little practice to learn the art of operating a slide rule and after it is learned, daily practice will insure its correct usage. A stop watch is a convenient method of registering time. The slide rule is likewise a quick and convenient method of converting that time into terms suitable for use in time-study work. Use your slide rule regularly until it becomes an automatic procedure with you.

Be sure to set the indexes and runner accurately to obtain an accurate answer. It is not compulsory to learn the method of locating the decimal point on your rule, but you will find that much time will be saved by fixing the decimal point by the method given in the text rather than by long-hand calculation or the so-called inspection method.

The data in this chapter relate to the use of a 5-in. slide rule because that size results in answers close enough for your time studies. An advantage of the 5-in. rule is that it can be easily carried in your vest pocket when at home or in the plant.

CHAPTER III

THE SLIDE RULE

An invaluable aid and timesaver is the slide rule for the figuration of time-study data. Many different types of mathematical formulas can be accurately solved by its use. The various people owning slide rules can be grouped into three classes:

1. Those who use the slide rule almost constantly for the direct figuration of data.
2. Those who use the slide rule only to check data previously worked out by long-hand method.
3. Those who use the slide rule so seldom that they have forgotten how to use it and for whom it, therefore, becomes an ornament.

Some time-study men employ slide rules to such an extent that a pencil is merely used to jot down answers. This can be safely done when the slide-rule scales are thoroughly learned and the readings of them are accurately noted. A person does not need to be an engineer to use the slide rule; many male and female office clerks are trained to use them and, in fact, in several factory offices, the clerks are paid daily bonuses as a result of their proficient use of them. These people are in the class 1 group. Until the T.S.M. has gained sufficient experience, he will find it advisable to place himself in class 2 for a while.

The slide rule recommended is known as a 5-in. Mannheim slide rule. It can be carried in your vest pocket and is instantly available for figurations that may be necessary when you are out in the plant. It is hoped that you will spend the short period of time required to learn its use and will practice daily until you can acquire speed in its operation and are sure of any readings drawn from it.

Almost all computations and answers to problems in this book were arrived at by slide-rule readings. The decimal fractions are extended only as far as accuracy demands. For example, instead of trying to set the constant 3.1416, used for determining

the circumference of a circle, on the slide rule, we set for 3.14 which is only three places or digits, instead of five places. The error by so doing is about $\frac{5}{100}$ of 1 per cent.

In Fig. 1, the names of the various parts of the rule are given. The slide, containing scales CF, CI, and C, moves sidewise in the channel, or grooves, in the fixed part, or body, of the rule. The body of the rule contains scales DF and D. The runner is a movable member containing a hairline used to locate coinciding points on the scales, to cover the intermediate results in the more involved figurations, and to indicate the answers to problems.

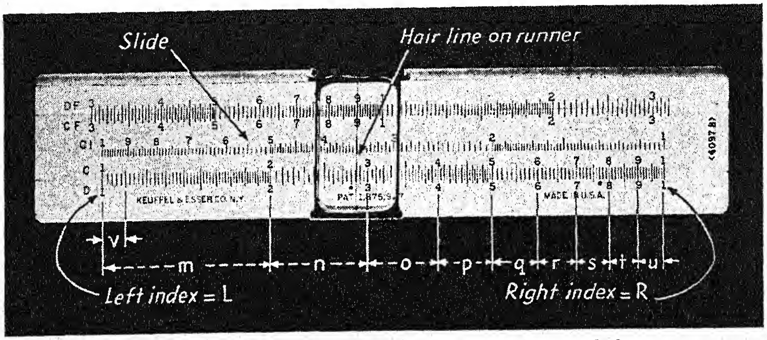

Fig. 1.—The style of 5-inch slide rule recommended.

Referring to scales C and D at the lower edge of the rule, you will see that they are graduated exactly alike. The starting point of the graduations is located at the left-hand side and each scale at the left is marked with the numeral "1." Each 1 at the left is known as the left index. Each graduation continues to the right and ends with another 1, which is known as the right index.

The main graduations on scales C and D are numbered—1, 2, 3, 4, 5, 6, 7, 8, 9, and 1. These same graduations are subdivided into smaller parts:

The section between the left index and the large "2" indicated by m is subdivided into 10 parts, one of which is noted by v, and again, these parts are further subdivided into five parts each. Confining ourselves to m, section between 1 and 2, we may set up arbitrary values for any of the graduations found therein (or for any other part of the slide rule). Assuming we have given to the left index a value of 100, then 2 at the end of the

section becomes 200. Reading the 10 largest graduated lines in the total *m* section, we draw off 100, 110, 120, 130, 140, 150, 160, 170, 180, 190, and 200. As stated, any values can be assigned to the graduations. For example, suppose the longest vertical graduated line on C or D scales almost halfway in section *m*, you called 150. This could be, instead, .0015 in., $1.50, $15, 150 castings, 150 yd. 1,500 miles, etc., and consequently the lines to the right or left of this line would represent larger or smaller numbers. The largest line at the end of *v* section (which indicates 1/10th of *m* section) would be read as .0011 in., $1.10, $11, 110 castings, etc.

Now taking up a further expansion of the 10 groups of graduations in *m* section, we find each of them subdivided into five graduations of 2/10ths each. Thus, in section *v* we read 10 as the index, then 10.2, 10.4, 10.6, 10.8, 11.0. To find, for illustration, 156 miles, we establish the left index as 100 and counting over, the next large line as at end of section *v* becomes 110, the second 120, and so on until we reach 150. Then when we consider the smallest lines, the first becomes 152 miles, the second, 154, and the third, 156 miles.

The *n* section representing the space between 2 and 3 is made up of 20 graduations. Every other graduation is marked by a larger line. Thus, the readings in section *n* are arrived at in the same fashion as in section *m*, except that in the former, each small graduation is 5/10ths instead of 2/10ths. *Example:* Find 285 on D scale. Setting up the 2 as 200 and counting over, we find 280 directly over the dot as indicated on D scale. Halfway between 280 thus found and 290 is the 285 reading which is shown immediately under the hairline in the illustration in Fig. 1.

The reader will find the graduations for groups *n*, *o*, and *p* are the same, except that the spacings grow finer (as do all others) as the graduations approach the right index. In view of the sameness of graduations between 3 and 5, it seems unnecessary to treat of them.

The sections represented by *q*, *r*, *s*, *t*, and *u* all have the same style of graduations and only 10 lines between them. Therefore, it may be said that numbers consisting of more than three digits are harder to read at the right-hand end of the rule than numbers of more than three digits occurring on the scales at the left-hand end.

One more example before we proceed to the next step: Find 775 on D scale. Directly over the dot in section *s* find 770. The next line to the right would be 780, so, placing the runner halfway between 770 and 780, a reading of 775 is found.

MULTIPLICATION

The process of multiplying one number by another number results in an answer called the *product*. Without attempting a lengthy technical discussion of why numbers can be multiplied and products obtained on the slide rule, we shall, instead, start with multiplication examples.

Problem.—Multiply 3 × 2.

Solution.—Move the slide to the right to bring the left index on C scale immediately over 3, which is found in the center of D scale. Thus the 3 is established as the first number called the *multiplicand*. Now slide the runner along until the hairline is directly over the *multiplier*, which is the large 2 found on the C scale. Reading the figure immediately under the hairline on D scale, find 6 as the product. Graphically, you found the product as follows:

(C scale) Set left index	Under other number	or	1	2
(D scale) On one number	Read product		3	Read 6

Problem.—Multiply 9 × 3.

Solution.—If the left index on C scale is placed over the 9 on D scale, it will be found that the slide projects so far to the right that the large 3 on C scale does not cover any number. Therefore place the right index on C scale over the 9 on D scale and, moving the runner to the large 3 on C, let the hairline cover one of the larger lines between 2 and 3 on D scale. However, since mental arithmetic tells you the product is 27, you then know the hairline is covering a number between 20 and 30 instead of 2 and 3. There are 10 larger lines or divisions between 20 and 30 and the hairline is found on the seventh line on D scale. So starting at 20, count over 21, 22, 23, 24, 25, 26, and 27, which is the product indicated by the runner. Again expressed in graphic form:

C	Set right index	Set runner on 3
D	On 9	Read 27

Problem.—$3\frac{1}{2} \times 2.8 = 9.8$.

Solution.—First of all, the common fraction of the first factor must be converted to a decimal fraction. So, by dividing the numerator by the denominator, a decimal fraction .5 is found. The problem now reads, $3.5 \times 2.8 = 9.8$, and is solved as follows:

C	Set left index	On 2.8
D	On 3.5	Read 9.8

In order that the reader may obtain practice, a table of various diameters and their corresponding circumferences is given below. Many of the figures in the table have been extended to five digits, which cannot be accurately set on the slide rule. However, the reader should set his rule as close as possible to the figures given and then compare the answers in the indicated columns. See explanation at end of table for procedure for each column.

TABLE 1

Item	(1) Diameter of circle, inches	(2) Diameter of circle, decimal equivalents, inches	(3) Circumference of circle, inches	(4) Area of circle, square inches
a	1/8	0.1250	0.3927	0.0123
b	1/4	0.2500	0.7854	0.0491
c	5/16	0.3125	0.9817	0.0767
d	3/8	0.3750	1.1781	0.1105
e	7/16	0.4375	1.3745	0.1503
f	1/2	0.5000	1.5708	0.1964
g	9/16	0.5625	1.7672	0.2485
h	5/8	0.6250	1.9635	0.3068
i	11/16	0.6875	2.1598	0.3712
j	3/4	0.7500	2.3562	0.4418
k	7/8	0.8750	2.7489	0.6013
l	1	1.0000	3.1416	0.7854
m	1 1/8	1.1250	3.5343	0.9940
n	1 1/4	1.2500	3.9270	1.2272
o	1 3/8	1.3750	4.3197	1.4849
p	1 1/2	1.5000	4.7124	1.7671

Figuration for column 3 = 3.14 (constant) × column 2.
Example: In item *a*, 3.14 × .1250 = .3927.

Columns 1 and 2 will be referred to later when *division* is explained. Column 4 will be used for examples when the next step in multiplication is considered.

The multiplication of several factors or numbers is easily performed on the slide rule.

Problem.—$2 \times 4 \times 6 = ?$

Solution.—Place the left index on 2 on D and move runner to 4 on C. Without disturbing the runner thus set, position right index to hairline. Now move runner to 6 on C and under the same on D, read 48 as product. The moves made were

C	Left index	Runner to 4	Right index to runner	Runner to 6
D	On 2			Read 48

Problem.—$1.5 \times 3.5 \times 2 = 10.5$.

Solution.—

C	Index	Runner on 3.5	Index to runner	Runner to 2
D	1.5			Read 10.5

The formula for obtaining the area of a circle is to square the diameter and then multiply the product by the constant .7854. Reducing to a more brief statement, we may express it as: diameter × diameter × .7854.

Referring to Table 1 and using column 2, the reader should check all areas in column 4. For example, in item *a*, the area is found as follows:

C	Index on	Runner on .125	Index on runner	On .7854
D	.125			Read .0123

DIVISION

The division of numbers, as you learned in arithmetic, is done by dividing one number (called the *dividend*) by the other number, which is called the *divisor*. The answer is called the *quotient*.

Division on the slide rule is a process that is the exact opposite of the multiplication method outlined. The difference is as follows:

	Multiplication		Division	
C	Set index on	On multiplier	Set divisor	On index
D	Multiplicand	Read product	On dividend	Read quotient

Problem.—Divide 4 by 2.

Solution.—Place runner on 4 on D scale, move 2 on C scale to runner, and under index read 2 as the quotient.

Problem.—Referring to Table 1, item *k*, reduce the common fraction ⅞ in column 1 to the decimal fraction found in column 2.

Solution.—Set runner on 7 on D scale. Now position 8 on C scale to runner and under index read quotient .875. The quotient was found:

C	8	Index
D	7	Read .875

The reader should practice division by converting all other common fractions in Table 1, column 1, to the corresponding decimal fractions in column 2.

MULTIPLICATION AND DIVISION

Problems consisting of a group of factors to be multiplied and divided are combinations of the multiplication and division slide-rule methods thus far treated.

Problem.—$2 \times 3/4 = 1.5$.

Solution.—Place left index on 2 on D, move runner to 3 on C, move 4 on C to runner and under left index, read 1.5.

Problem.—$\dfrac{3 \times 4 \times 6 \times 2}{1.2 \times 2.5 \times 16 \times 1.5} = \dfrac{144}{72} = 2.$

Solution.—The figuration can be worked by at least two different ways. The first way is to carry through all multiplication of the factors above the line to obtain the numerator 144 and after this is done and noted, the factors below the line are multiplied to arrive at 72 for the denominator. Afterward, the fraction $^{144}/_{72}$ is divided to obtain the final quotient.

The other way, which will be better understood by the reader after he has gained more experience in the use of the slide rule, is to use the direct method, which, for the problem above, is as follows: Set runner on 3 on D, place 1.2 on C on runner, move runner to 4 on C, move 2.5 on C to runner, move runner to left index on C, change indexes by placing the right index on C under runner, move runner to 6 on C, move 16 on C to runner, move runner to 2 on C, move 1.5 on C to runner and under left index, read 2 as the quotient.

PROPORTION

Ratio and proportion principles are used as a basis of the rating method, which is taken up in Chap. IV. The slide rule is so easily adaptable for ratio and proportion that it should be used exclusively for this type of figuration.

The equality of ratios is called *proportion*. The numbers making up the proportion are called *terms* and always applied from left to right, as in the following example (T = term):

$$\frac{\text{First } T}{9} \text{ is to } \frac{\text{Second } T}{3} \text{ as } \frac{\text{Third } T}{6} \text{ is to } \frac{\text{Fourth } T}{2}$$

Signs are used to express the equation, $9:3 = 6:2$. The first and fourth terms are called the *extremes* and when multiplied together the product should be the same as the product of the *means*, which are the second and third terms.

Problem.—$5:2.5 = 4:x$.

$$\frac{\text{C}}{\text{D}}\left|\frac{\text{Set first } T}{\text{Second } T}\right|\frac{\text{Under third } T}{\text{Read fourth } T} \text{ or } \frac{\text{C}}{\text{D}}\left|\frac{5}{2.5}\right|\frac{4}{\text{Read } 2}$$

Problem.—If an operator in 3 hr. can produce 150 drilled and reamed castings, how many can he produce in 5 hr.?

Solution.—$3:150 = 5:x$.

C	3	5
D	150	$x = 250$

Where C scale is used for the first and third terms.

C	150	$x = 250$
D	3	5

Where D scale is used for the first and third terms.

Exercise 1

Find the value of x in the following:

1. $16:48 = 25:x$. *Ans.* $x = 75$.
2. $4:x = 30:42$. *Ans.* $x = 5.6$.
3. $72:80 = x:30$. *Ans.* $x = 27$.
4. $2.8:34 = 1.4:x$. *Ans.* $x = 17$.
5. $21:26 = 101:x$. *Ans.* $x = 125$ approx.

PERCENTAGE

The T.S.M. finds that many different percentage problems occur in his work and that the slide rule offers a convenient means for solving them.

To refresh your memory covering percentage figuration, the general terms are given:

b = base................	The number on which the per cent is to be taken.
r = rate................	The number of hundredths of the base to be taken.
p = percentage..........	The portion of the base determined by the rate.
a = amount............	Is the sum of the base and percentage.
d = difference...........	Is the result found by subtracting the percentage from the base.
% = per cent sign........	The use of this sign signifies that the number is expressed in hundredths. *Example:* 8% = .08, 9½% = .095, 115% = 1.15.

Using the symbols, the various formulas for percentage calculations are

(1) $p = b \times r$ (2) $r = p/b$ (3) $b = p/r$
(4) $a = b(1 + r)$ (5) $d = b(1 - r)$
(6) $b = a/(1 + r)$ (7) $b = d/(1 - r)$

Exercise 2

1. Use formula (1). Out of a lot of 220 lawn mowers sent to inspection, 35 per cent were rejected. How many were bad? *Ans.* $220 \times .35 = 77$.

2. The total number of employees in a plant is 2,500, consisting of 26 per cent females and 74 per cent males. How many female and how many male employees are there in the plant? *Ans.* Females = 650; males = 1,850.

3. A department has 92 operators, 75 per cent of whom are direct workers. How many indirect workers are there? *Ans.* 23.

4. Use formula (2). A careless gear-hobber operator spoils 15 out of a quantity of 90 gears sent to him to be cut. What percentage of the total did he spoil? *Ans.* 16.7 per cent.

5. The manager asks the T.S.M. how many studies he has completed out of a total of 620 studies to be taken in a large assembly room. The T.S.M. informs him that 565 are finished. What is the percentage of completion? *Ans.* 91 per cent.

6. Use formula (3). An operator is requested to refit 162 shafts, which is 12 per cent of the total originally sent to him. What was the total? *Ans.* 1,350.

7. Out of a quantity of steel castings received from the foundry, it was found that 4.5 per cent of them were too hard and that this represented 108 castings that could not be machined. How many castings were there in the total quantity? *Ans.* 2,400.

8. Use formula (4). The purchasing department wrote to a firm to increase the order of 325 wire baskets placed with them by 60 per cent. What was the new amount on order?

Solution.—325(1 + 60 per cent) = 325 × 1.60 = 520 wire baskets.

9. Add a rest factor of 15 per cent to 3.3 min. *Ans.* 3.8 min.

10. A piecework price of $.065 was increased 20 per cent because of changed design. What is the new piecework price per piece? *Ans.* $.078.

11. Use formula (5). In a shipment of 5,000 yd. of cloth shipped from a textile mill, 25 per cent of the yardage was improperly made. How many good yards were there? *Ans.* 5,000 × .75 = 3,750 yd.

12. Owing to a slack season, only 65 per cent of the 800 total machines were in operation. How many machines were idle? *Ans.* 280.

13. Use formula (6). A time study, including a fatigue factor of 12 per cent, prescribes a time allowance of 7.0 min. If the fatigue factor is removed, what is the net time allowance? *Ans.* 7.0 ÷ 1.12 = 6.25.

14. The operation list for a part calls for 5 per cent of the operations to be reworked, making a total of 40 operations to be performed. How many operations would be necessary if none was reworked? *Ans.* 38.

15. Use formula (7). Because of a loose belt, a punch press makes only 105 strokes per minute, which is the result of 16 per cent loss in its capacity. What is the capacity of the press with a tight belt? *Ans.* 125.

16. In taking an inventory, the superintendent stated that the job was 65.5 per cent completed and that only 145 more items were to be taken to finish the whole job. How many items were there in the whole job? *Ans.* 420.

THE POSITION OF THE DECIMAL POINT

The location of decimal points in slide-rule problems is usually determined by inspection, but there are times when one is not

sure of his visual inspection and resorts to long-hand calculations to verify his inspection.

A definite rule for locating decimal points on the slide rule will be given. The reader who has had elementary algebra in his schoolwork may digest the rule more quickly than one who has not touched on that branch of mathematics.

Numbers to be multiplied or divided each have a part called the *characteristic*. The characteristic of a number is the amount of figures or digits to the left of the decimal point in a whole or mixed number. In a number that is only a decimal fraction of a whole number, the characteristic is the amount of ciphers that precede the significant digits to the right of the decimal point. *Examples:*

In	2,320.	the characteristic is	4
In	232.0	the characteristic is	3
In	23.20	the characteristic is	2
In	2.320	the characteristic is	1
In	.2320	the characteristic is	0
In	.02320	the characteristic is	−1
In	.002320	the characteristic is	−2
In	.0002320	the characteristic is	−3

The determination of characteristics for each factor is the first step in the rule for finding the location of the decimal point. The addition or subtraction of the characteristics for the factors is the next step.

In algebra, the addition of numbers having *like* signs requires the sum to carry the same *common sign.* *Examples:*

$$\begin{array}{r} +5 \\ +3 \\ \hline +8 \end{array} \qquad \begin{array}{r} +50 \\ +29 \\ \hline +79 \end{array} \qquad \begin{array}{r} -6 \\ -3 \\ \hline -9 \end{array} \qquad \begin{array}{r} -70 \\ -15 \\ \hline -85 \end{array}$$

In algebra, the addition of numbers having *unlike* signs first requires the subtraction of the lesser number from the larger and then the sign of the greater number is specified for the *difference* found. *Examples:*

$$\begin{array}{r} +5 \\ -3 \\ \hline +2 \end{array} \qquad \begin{array}{r} +2 \\ -8 \\ \hline -6 \end{array} \qquad \begin{array}{r} -7 \\ +9 \\ \hline +2 \end{array} \qquad \begin{array}{r} -6 \\ +1 \\ \hline -5 \end{array}$$

In algebra, the subtraction of numbers having either like or unlike signs first requires the changing of the sign in the sub-

trahend regardless of whether the subtrahend carries a plus or minus sign. After this is mentally done, proceed as in the addition methods just explained.

The following examples of algebraic subtraction show the results which are called *differences*, with the correct sign attached to each difference. The examples appear unchanged in problems; the reader mentally changes the subtrahend signs and proceeds in each case as for addition.

$$\begin{array}{rrrrrrrr} +5 & +50 & -6 & -70 & +5 & +2 & -7 & -6 \\ +3 & +29 & -3 & -15 & -3 & -8 & +9 & +1 \\ \hline +2 & +21 & -3 & -55 & +8 & +10 & -16 & -7 \end{array}$$

To arrive at these differences above, the reader mentally changed each subtrahend and then proceeded as in algebraic

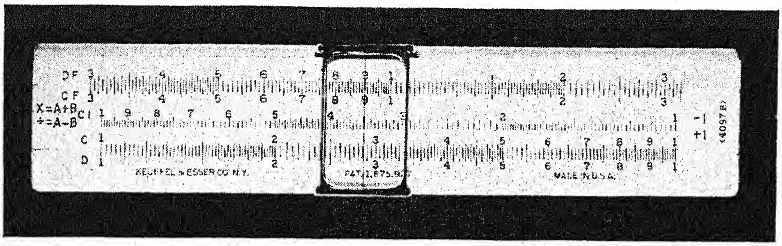

FIG. 2.—The right- and left-hand ends of the slide rule show the formulas for locating the decimal-point position which are often etched on the slide rule by the time-study man.

addition, which, as stated, requires that the sum must take the sign of the larger number. Therefore, the above examples were mentally changed to read as follows:

$$\begin{array}{rrrrrrrr} +5 & +50 & -6 & -70 & +5 & +2 & -7 & -6 \\ -3 & -29 & +3 & +15 & +3 & +8 & -9 & -1 \\ \hline +2 & +21 & -3 & -55 & +8 & +10 & -16 & -7 \end{array}$$

Having learned the principles of characteristics as the first step and the addition of positive and negative numbers as the second step, the reader can make application of these two steps to the slide-rule figurations.

Since the slide rule is based on logarithms, multiplication is merely the addition of logarithmic numbers and division is based on the subtraction of them. Limiting ourselves to the use of

these laws as applying to characteristics, we then have for slide-rule figuration the following procedure:

When the slide on the rule projects to the LEFT	When the slide on the rule projects to the RIGHT
$\times = a + b$	$\times = a + b - 1$
$\div = a - b$	$\div = a - b + 1$

Many time-study men take a knife point and etch condensed formulas of the above on their slide rules somewhat as in Fig. 2.

The a and b symbols are used to denote the characteristics of the numbers in multiplication or division. The following exercises cover their use:

Exercise 3

1. 8,200 × 50	= 410,000	characteristics = 4 plus 2	= 6 total
2. 8,200 × 5	= 41,000	characteristics = 4 plus 1	= 5 total
3. 8,200 × .5	= 4,100	characteristics = 4 plus 0	= 4 total
4. 8,200 × .05	= 410	characteristics = 4 plus −1	= 3 total
5. 8,200 × .005	= 41	characteristics = 4 plus −2	= 2 total

In this group, the slide projected to the left.

6. 230 × 27	= 6,210	characteristics = 3 plus 2 minus 1	= 4 total
7. 230 × 2.7	= 621.0	characteristics = 3 plus 1 minus 1	= 3 total
8. 230 × .27	= 62.10	characteristics = 3 plus 0 minus 1	= 2 total
9. 230 × .027	= 6.210	characteristics = 3 plus −1 minus 1	= 1 total
10. 230 × .0027	= .6210	characteristics = 3 plus −2 minus 1	= 0 total
11. 230 × .00027	= .0621	characteristics = 3 plus −3 minus 1	= −1 total

In this group, the slide projected to the right.

12. 413 ÷ 59	= 7	characteristics = 3 minus 2	= 1 total
13. 413 ÷ 5.9	= 70	characteristics = 3 minus 1	= 2 total
14. 413 ÷ .59	= 700	characteristics = 3 minus 0	= 3 total
15. 413 ÷ .059	= 7,000	characteristics = 3 minus −1	= 4 total

In this group, the slide projected to the left.

16. 8,200 ÷ 50	= 164	characteristics = 4 minus 2 plus 1	= 3 total
17. 8,200 ÷ 5	= 1,640	characteristics = 4 minus 1 plus 1	= 4 total
18. 8,200 ÷ .5	= 16,400	characteristics = 4 minus 0 plus 1	= 5 total
19. 8,200 ÷ .05	= 164,000	characteristics = 4 minus −1 plus 1	= 6 total

In this group, the slide projected to the right.

When the reader is working percentage problems, he will sometimes make an error of two decimal places. This is usually traced to the fact that he failed to remember that per cent

means "by the hundred." Thus, 10 per cent might easily be written 10. instead of .10 and thereby cause the error referred to above.

Until the reader has thoroughly mastered the slide rule, he may misread graduations. Many misreadings are apt to occur at the left-hand end of the rule. For instance, setting an index to 1,001, 101, 110, or 11 will often prove confusing unless proper thought is given to such numbers.

The reader can obtain daily practice by working out tables and tabulations given in handbooks. Also, in newspapers, various advertisements specify sales prices and give new and old prices and percentage of reduction. Other data offering excellent slide-rule problems can be found in periodicals.

Until your slide rule has had considerable use, the slide may not operate freely. If a little beeswax or paraffin is applied to the top and bottom edges of the slide, you will find that it will keep the slide operating smoothly. Do not apply oil or grease to the slide or talcum powder to the rule. Should the rule become soiled, use a cloth dampened with water to rub lightly the top surface of the rule.

Only scales C and D have been covered in this chapter.

Problems

1. What is the circumference of a 7½-in. diameter shaft? Specify the answer to three places.

2. What is the area of a 2½-in. diameter circle? Specify the answer to three places.

3. Divide 32.75 by 5.2 specifying the answer to three places.

4. Solve: $a/b \times c$ where $a = 162$, $b = 2.4$, and $c = 5$.

5. If 5 men can produce a total of 40 units per hour, how many units can 8 men produce in the same length of time?

6. If 75 lb. of steel costs $2.25, what would 140 lb. cost? In addition to submitting the answer, the reader should write out briefly the slide and runner moves he was required to make in this proportion problem to arrive at the answer.

7. Using formula, $\dfrac{\text{C}}{\text{D}} \left| \dfrac{\text{Diameter}}{3.82} \right| \dfrac{\text{Read F.P.M.}}{\text{r.p.m.}}$, work this problem. The T.S.M., in checking the speed of a boring mill that is boring a hole 4.25 in. diameter in a brass casting, finds the casting is revolving 126 r.p.m. What is the F.P.M. (feet per minute)?

8. To the price of $110 covering an electrical attachment for a toolroom device, was added a 10 per cent installation charge. What was the total money spent?

9. In a total time allowance of 34.5 min. for a spinning operation, 6.1 min. was incorporated to cover walking time. What percentage of the total time was allowed for walking?

10. A grinding wheel running at 2,400 r.p.m. has become so reduced in diameter that a 25 per cent loss in production is had. What should the revolutions per minute be changed to in order to overcome this loss?

Answers to Questions

1. Circumference = diameter × pi = 7.5 in. × 3.14 = 23.6 in.

2. Area = .7854 d^2 = 2.5 in. × 2.5 in. × .7854 = 4.91 in.

3. 32.75/5.2 = 6.3

4. 162/2.4 × 5 = 13.5.

5. 5:40 = 8:x. x = 64.

6. 75:\$2.25 = 140:x. x = \$4.20. In solving this problem, 75 on C scale is placed on \$2.25 on D scale, the runner is moved to right index, the indexes are changed, the runner is then moved to 140 on C scale, and under the same on D scale, \$4.20 is read as the answer.

7. $\dfrac{\text{C}}{\text{D}}\left|\dfrac{4.25}{3.82}\right|\dfrac{\text{F.P.M.}}{126 \text{ r.p.m.}}$ F.P.M. = 140.

8. \$110 × 1.10 = \$121.

9. $r = p/b$ = 6.1/34.5 = 17.7 per cent walking time.

10. $b = d/(1 - r)$ = 2,400/.75 = 3,200 r.p.m.

Chapter IV

Establishing time values based on the performance of the fastest operator in a group of workers is an improper practice. Nor should the method be followed of selecting the maximum, average, or minimum watch readings obtained. No stop-watch posting should be made unless there is a symbol of effectiveness attached which will place a definite, weighted time value for it. A stop-watch reading has no meaning unless it is evaluated.

The rating method is the basis for the evaluation of watch readings. Many examples and suggestions are given to perfect your ability to specify properly the ratings to accompany your watch readings. Instead of picking some particular individual on whom you will base your time measurements, the rating method will enable you to time-study any one regardless of his speed and quickly convert the watch reading to the correct time posting.

Like the slide rule, the rating method can be successfully used after considerable practice. This chapter on rating will suggest many ways of seasoning your rating ability through daily application of its principles.

CHAPTER IV

THE RATING METHOD

The author believes the rating method for general use is the proper means of obtaining a true measure of the speed of a workman and of the results of his speed.

Time-study men are realizing more each day that some definite information regarding the performance of an operator should be recorded on time-study observation sheets. It is not enough merely to post the stop-watch readings for the various elements in an operation; the watch readings should be qualified by symbols which represent the value of the times determined by the stop watch. To study an operator with whose capacity you are not familiar, the minimum, average, and maximum times secured from him do not necessarily indicate the true value of the time elements found. A very poor operator, by his erratic performance, will also reflect minimum, average, and maximum watch readings, yet no credence can be placed in their value. Again, studies may be taken on so-called super-type operators and the time values set up from them are unfair for use by the average type of operator.

Thus, we may establish another time-study law: *Time measurements must be qualified by information that evaluates stop-watch readings.*

Any average person possesses the ability to "size up" people or things. This ability is commonly based on judgment which is keener or more mature in one person than in another. No matter how immature a person's judgment may be, he can, nevertheless, distinguish a difference between things that are very heavy and unusually light; large and small; fast and slow. In other words, if the difference between two things is pronounced, the average person will recognize the extremities. Between these extremities may be set up a range or scale of shades, symbols, percentages, or other suitable factors to identify the intermediate stages of the extremities. To recognize these intermediaries requires judgment developed to a higher degree.

In large stockyards, a man stands at the runway and as each animal passes him, he glances at it and calls out a poundage that is recorded as the official weight of that animal. His judgment is so keen and his rating ability so accurate that if each animal had been weighed on regular platform scales, the total day's weight would vary but a few pounds from the sum of the weights estimated by the rater.

A good contractor can estimate the number of cubic yards of soil in a large hill which is to be removed and when the job is finally completed, it will be found that his rating of the job is uncannily close to the actual yardage handled. Clever traffic policemen can judge speeds, experts can estimate numbers of people in large crowds, professional appraisers can quickly place values on objects under consideration. Many other illustrations could be offered of experts who arrive at their decisions promptly, without guesswork and without reference to voluminous data.

The T.S.M. must be an expert in judging the speed of a workman and also the effect of the speed. Regardless of whether the worker is slow, medium, or fast, the degree of his speed must be translated into terms of time that can be applied as values for stop-watch readings.

In using the rating method, it is not necessary to select certain workmen to secure satisfactory studies. All plant officials do not realize the evils that are apt to result from the practice of having studies made on professional demonstrators or on the fastest operator in a group of men. Demonstrators are not always the best men to study and oftentimes are not held in high esteem by the rest of the employees. Unless the demonstrator is exceptionally broadminded, he may attempt to "get back" at a shopmate for whom no love is lost, by a demonstration that yields a tight piecework price or time allowance. The fast operator in a group of men does not enjoy having standards predicated on his efforts, because he fears the criticisms of the slower men who complain to him about the task set. The fact that a T.S.M. will not study exclusively the fastest man in a group encourages the idea that the standard will be fair.

Instead of attempting a description of speed, such as "slightly better than average," "between slow and fair," etc., the rating method uses symbols to express the various degrees of speeds.

These symbols are really expressions of time. Thus, in the table which follows, if an operator is given a rating, say of 65, it means that he performed the element at a speed which is a little faster than normal, and if he maintained that same speed constantly, he would be 65/60ths faster than the clock on the wall. Thus, the clock on the wall should rightfully be changed to have 65 min. in the hour instead of the conventional 60 min. to measure his performance properly. If he were given 60 as a rating for his next element, it means that so far as that particular element is concerned, he is neither faster nor slower than the 60-min. clock and consequently is normal. Being normal, he is not entitled to extra pay in the form of time allowance or piecework earnings over his regular hourly rate.

The rating method is based on the following:

Table 2

Symbols	Speeds
100	Superfast
95	Fast Plus
90	Fast
85	Fast Minus
80	Excellent
75	Good Plus
70	Good
65	Good Minus
60	Normal
55	Fair Plus
50	Fair
45	Fair Minus
40	Poor

An example will best illustrate the use of the symbols. Assume an operator is given the job of filing off a sharp edge on a casting. First he must pick up one casting from a barrel, then secure the casting in his bench vise, file off the sharp edge, remove the casting from the vise, and finally place the finished casting in a stack of other completed castings on a near-by truck. This cycle of work would be split into elements, somewhat as follows:

A. Pick up one casting from supply barrel 5 ft. away.
B. Position and tighten in vise.
C. Pick up file and completely remove sharp edge.
D. Lay down file and loosen vise.
E. Away with casting and stack on truck 10 ft. away.

The T.S.M. notices that the operator is faster on some elements than on others and, besides recording the watch readings, he rates the operator on the study of five castings or cycles, as follows:

Element

A. Watch readings: .06 – .07 – .06 – .07 – .07 @ 65R. Operator is slightly better than normal, so is given a rating of 65.

B. Watch readings: .04 – .04 – .05 – .04 – .05 @ 80R. Operator shows brisk speed, so is given 80 rating.

C. Watch readings: .22 – .24 – .22 – .25 – .22 @ 50R. Operator takes too long to file and examine each casting, so is given a 50 rating.

D. Watch readings: .03 – .03 – .04 – .03 – .04 @ 75R. Operator exhibits a speed a little better than good, so is given a 75 rating.

E. Watch readings: .08 – .09 – .09 – .08 – .08 – @ 60R. The operator performed this element at an average rate, so was given 60 for his effort.

In the foregoing example it is noted that, besides the net watch readings for each element, different ratings were prescribed for the same operator. The reconciliation of the watch readings will be explained later on in this chapter.

When a 60 rating is granted to an operator for an element, or perhaps for the whole operation, it means that, regardless of how fast or skilled he ordinarily might be, he exhibited an average effort only for that phase of the work in question and therefore is only entitled to a normal rating. His performance is no more or less than the normal performance of the clock on the wall, which regularly completes a cycle of 60 min. every hour. If consistently normal, the operator produces 60 min. worth of work every hour and consequently is only average; he is neither fast nor slow. Based on this analogy, a normal or average operator should receive no more or less wages than the average basic hourly wage paid for the type of job upon which he is working.

Thus, we may establish another law: *A normal worker is an average type of worker, performing at an average rate of speed, under average working conditions and, as a result, produces an average daily production of average quality.*

From compiled industrial data covering many plants that have attractive wage-payment incentive plans which result in excellent quality of product at low unit costs, it was learned that the group average speed of the operators in each plant was 33⅓ per cent faster than normal.

An 80 rating, as proved by your slide rule, is $33\frac{1}{3}$ per cent or one-third faster than a 60 rating. Thus, we find that the data found from the surveys of the above-mentioned plants showed that they were entitled to 80 ratings. Consequently, we may safely set up an 80 rating as the ideal effort-goal in manufacturing.

The speed and effort which a suitable operator displays and the accomplishment attained on a job carrying a proper piece-work price may be compared to an 80 rating. In either case the speed is not slow, nor excessively fast; rather it is a good brisk rate of speed that produces a first-class quality of work in a period of time that is not injurious to the operator or equipment. As stated, since an 80 should be attained for a group average, it follows that operators who fall below the 80 classification must be balanced by those who enjoy ratings higher than 80.

The official definition of an 80 rating may be described: *An average workman producing excellent work, under average conditions, at a brisk, maintainable rate of effective speed.*

Many outstanding operators, by reason of their superior skill and speed, eliminate all false movements and delays and achieve a rhythm of motion that results in high productivity and entitles them to 85 to 95 ratings. One instance may be cited of an unusually clever girl spooler-tender in a textile mill who consistently made 125 ratings every day. The standards for the spooling operations were correct because other skilled girl spoolers averaged only 80 to 85 per day on the same spooling operations.

A T.S.M. generally finds it easier to study and rate operators working at 60 or more, because he does not have to reconcile so many erratic movements, delays, and other factors that occur in large numbers in demonstrations by workmen who receive less than 60 ratings. Until the T.S.M. has equipped himself with a complete knowledge of rating and has gained sufficient experience, he will find it more difficult to rate below 50. The study of operators whose ratings are much below normal reveals many abnormal things. A few of them are

Lack of mental or physical qualifications for the job.
Lack of seasoned training.
No interest in their work.
Slowness of movement and performance.
Failure to do job in the official manner.

Introduction of foreign movements to the cycle.
Lack of coordination between mind and body.
Desire to give "sleigh ride" to T.S.M.

Ratings applied to slow men must be very carefully considered, as any error on slow ratings becomes strongly pronounced. A 5 point error between 20 and 25 is 25 per cent disagreement, whereas a 5 point error between 75 and 80 is only $6\frac{2}{3}$ per cent. It would seem, therefore, that unless the T.S.M. is skilled, he will have trouble in arriving at proper time values for ratings much below 50R. If an operator is capable of better demonstration but is only trying to fool the T.S.M., it can often be traced to the wrong contact of the T.S.M. However, if the operator is honestly trying but cannot yield results, then that operator should not have been receiving the standard wage for his efforts and should be placed on another type of operation where his talents are equal to the specifications of the task.

With reference again to Table 2, we believe that the intermediate ratings between and beyond 60 and 80 are so self-evident as to require no explanation. If you have personally engaged in, or are familiar with, the type of work that you are studying, you will quickly recognize, without a great amount of seasoned time-study experience, the exact degree of speed the worker under observation is displaying on his job. The study of jobs the details of which are foreign to you becomes a task that can be handled only after you have acquired more time-study experience and have matured your rating ability. A T.S.M. need not be a skilled craftsman in any given field in order to time-study successfully any or all work in that field.

Regardless of the systems used in various manufacturing plants, the fundamental basis of them is time. Piecework systems must first know the length of time necessary to complete one piece properly before any price can be assigned. Other forms of systems, particularly premium systems, have as their genesis the basis of time. Also, most modern systems demand data converted to a normal or average basis which can be used as an index to determine many things, a few of which are stated here:

How fast or skilled their workers are.
How much production each worker should produce.
How to establish a base pay before premium or bonus is paid to experienced operators.

How to establish learners' wage rates and what production should be expected from them.

How to take care of old employees, who, on account of advancing age, cannot produce their former volumes.

How to determine efficiencies based on actual and standard hours.

The next step in the principles of rating is to convert all watch readings to normal by reconciling the watch readings with the rating symbols attached to the readings. To normalize a watch reading is to reduce or increase it (depending, of course, on the rating) to a 60 basis by means of this formula:

$$\text{Normal} = \frac{\text{actual watch reading} \times \text{rating}}{60}$$

or

$$\text{N.} = \frac{A \times R}{60}.$$

Example.—An operator completes an element in a cycle in 2.6 min. and is given a rating of 75. How long will it take a normal man to do the same element?

Solution.—2.6 × 75/60 = 3.25 min. Indicated as 3.25N.

Example.—A very slow laborer handling pig iron is given a rating of 45 for his effort in unloading a gondola car. He averaged .16 min. per ingot. What is the normal per ingot?

Solution.—.16 × 45R./60 = .12N.

Converting actuals to normals is a problem in proportion and can be quickly solved on your slide rule. Two methods are given as follows:

C	Set 60 over	Under rating
D	Actual time	Read normal

or

C	Set 60 over	Under actual
D	Rating	Read normal

Referring to page 66, the watch readings in the example elements *A* to *E* inclusive are normalized as follows:

Exercise 4

A = .06; .07; .06; .07; .07 = .33/5 = .066 @ 65R. = .072N.
B = .04; .04; .05; .04; .05 = .22/5 = .044 @ 80R. = .059N.
C = .22; .24; .22; .25; .22 = 1.15/5 = .23 @ 50R. = .192N.
D = .03; .03; .04; .03; .04 = .17/5 = .034 @ 75R. = .043N.
E = .08; .09; .09; .08; .08 = .42/5 = .084 @ 60R. = .084N.
Total = .450N.

Although averages of watch readings were used in the foregoing exercise to normalize the five elements, the average basis should not always be used, because in many time studies the fluctuations in watch readings are so great that a different procedure is required for the selection of the actuals to be normalized.

The total normal of .450 min. as shown in Exercise 4 is by no means a standard. Time allowances to cover all proper delays, variables, incidentals, rest factors, etc., must be added to the sum of normals before the total times can be considered as standards.

A rating prescribed for an element should never include rest. The rating allowed is a measure of effective speed, whereas the rest factor later added is the means of insuring that speed.

Ratings are also applied to machines. When a machine is running at the proper feeds and speeds and produces a satisfactory product without injury to operator, machine, or material, the machine is given an 80 rating for the actual machine time, but watch readings covering same are never normalized. However, to restate a previously outlined principle—rated watch readings on labor are *always normalized.*

An analysis of each element in an operation should be made before applying ratings.. An operation may be of such nature as to require a nimble type of operator whose slowest movements appear fast. For example, the speed of a typist may appear so fast to you as to warrant a high rating, yet that typist in comparison to other typists may be quite slow. On the other hand, a hod carrier in going up a long ladder with a load of bricks on his shoulder cannot be expected to display the alacrity of a fast-walking man on level ground. Therefore ratings should be contemplated in the light of the work being done.

Although the ratings for all elements should be correct, some latitude may be allowed for the ratings of short elements where a slight error would not be appreciable, because of the small percentage of time the inaccurately rated element bears to the whole cycle.

Before starting observations on any operations, the T.S.M. should not investigate production records or inquire about the output per hour of the operator on the job that is to be studied. It so often happens that the new volume of production

called for by correctly made studies is so much greater than the regular volume produced that a knowledge of the regular volume might militate against his judgment and cause him to waver in the judicious application of his ratings. However, during the training period of a T.S.M., the knowledge of the production turned out per hour by certain operators whose speed he is appraising sometimes offers a means of comparing or confirming the ratings he has specified for practice work.

One method of seasoning your rating ability is to observe several men, all of whom are engaged on the same kind of work. Without using your stop watch, observe at least two of them who are working at noticeably different speeds on the same job and for whom you are to apply ratings. Observe the two for a while and, during this period of observation, specify on a piece of paper your idea of the speed rating for each. At the end of the period, find out how many pieces, pounds, shovelfuls (or whatever it may happen to be) each of two persons under your observation produced during that period. Then, with your slide rule, compute the error of your ratings. For illustration, say, you are observing two men whom you call *A* and *B*. Awaiting the exact moment when they both throw a finished piece of work on the floor, you officially start your observation. Suppose you have given *A* the rating of 65R. and *B* a rating of 75R. and during the unknown period of time they each produced several pieces but of varying quantities. At the instant when they each again throw a finished piece on the floor, you concluded your observation. Now find how many pieces each produced during your observation time. Supposing further, assume that *A* at a uniform speed and without delays completed 15 pieces and *B* at his uniform speed and without delays completed 17 pieces. Your slide rule setting becomes:

C	Set 65R. on	Read 73.7R.
D	15 castings	On 17 castings

Assuming your rating of *A* was correct, you missed *B*'s rating by 1.3 points, or $(75 - 73.7)/75 = 1.7$ per cent less than your 75R.

As another test, using your stop watch, time two men on some other kind of work, but both of whom are doing the same thing.

Specify your rating for C and also for D. Supposing you have given C a rating of 70R. for the one piece he completed in .36 min. and for D you have specified a rating of 55R. for his piece which he completed in .46 min. Your slide rule will show less than one point of error.

$$\frac{\text{C scale}}{\text{D scale}}\left|\frac{.46}{.36}\right|\frac{70\text{R.}}{54.8\text{R.}}$$

Still another way of confirming your ratings is to observe two or more operators working on the same job and to write down your ratings for each of them. Afterward, if you have access to production records or can inquire of your foreman what each of the operators customarily produces per hour, you can check the correctness or error of your ratings in the same way as in the two preceding illustrations.

Example.—A piecework operator whom you consider an 85 worker, states that he has one piecework job that keeps him going at a brisk pace all of his 8-hr. day, but that another of his jobs takes only 7 hr. He stretches out the latter job to 8 hr., fearing that it might be cut by the inexperienced T.S.M. who studied it. What rating would you apply to this 85 operator when he takes 8 hr. to do the 7-hr. job?

Solution.— $\frac{\text{C}}{\text{D}}\left|\frac{\text{Set 8 hr.}}{\text{On 7 hr.}}\right|\frac{\text{On 85R.}}{\text{Read 74.4}}$ Call answer 75R.

Example.—A man of average height, walking at a normal rate of speed on level ground, requires .00368 min. to walk one foot of distance. What is the normal time for him to walk 875 ft.?

Solution.—$.00368 \times 875 = 3.22$ min. N.

The United States Army Regulations specify that when soldiers are marching at attention, they should take 30-in. steps and average approximately 128 steps per minute. This information, based on 3.64 miles per hour, is, together with several other sources of information, averaged to establish walking-time data for time-study work. Walking data are further treated in Chap. XIII. The reader, by this time, should have started a notebook of pocket size to list the formulas that have thus far been given in this and preceding chapters. In his notebook should be entered the following data:

Normal Walking-time Data for an Average Man

.00368 = minutes per foot
271.7 = feet per minute
3.09 = miles per hour

These data will allow a normal man to carry a load of 5 lb. maximum while walking but do not include rest or delay allowances, which should be added to compensate for unusual walking conditions or heavy weights carried.

From the foregoing walking data, the reader can obtain practice by rating and timing people walking between two given points. *Example:* The boundary lines of the property on which the home of a reader is located have a total of 125-ft. frontage. From his porch he time-studies and rates the speed of various people walking the 125-ft. distance. He prepares a work sheet, somewhat as follows:

Exercise 5

Person number	My rating	Actual time, minutes	True rating	Rating error, points
1	70R.	.41	67.3	2.7
2	40R.	.65	42.5	2.5
3	95R.	.29	95.2	.2
4	60R.	.46	60.0	0.

Distance = 125 ft. Time = 125 × .00368 = .46 min. N.

Use the slide rule to obtain the true rating in the above exercise. On actual watch reading on D scale, set 60 on C scale. Place runner on the product of distance × .00368 (in this case, .46 min. N) and read true posting on C scale.

Thus far in this chapter, the fundamental principles for the judging of speeds have been outlined. Speed without accomplishment means nothing. Besides being able accurately to judge speeds, the T.S.M. must further develop his sense of proportion in order to measure the accomplishments of speed. Thus, a rating is a composite of speed and its effect.

A man might use a heavy hammer and by a few deliberate blows drive home a large spike in a hard plank with little effort. That same man, using a jeweler's hammer will make but little progress, no matter how hard or rapidly he struck another spike in the same plank. The first example is classed as a slow-moving job that earns its 80 by reason of its effectiveness. The second example illustrates the fact that no effect is obtained from speed.

The muscular effort required for a heavy, laborious kind of work has no influence upon rating. A job might require a man of unusual physical strength and but few pieces or cycles are completed per day. On the other hand, a girl operator may be engaged on a very light class of work that demands dexterity and nimbleness and her many cycles per day will yield thousands of pieces. Assuming that in each case both were producing at 80, no comparison can be made of the volume or total weight of production between the man and the girl, yet, so far as the effectiveness of effort is concerned, both are entitled to the same degree of credit. In each case suitable types of individuals were selected and rest factors together with other time allowances were allowed to maintain the effectiveness of each.

In plants where production is of such volume that it requires many operators on perhaps just one operation, it is interesting to watch each of the workmen, all of whom may be diligent in their endeavors but none of whom work or produce alike. One operator might seem to be a veritable beehive of industry on account of his rapid movements and at first glance might receive, erroneously, a high rating for a later recognized ineffectiveness. In contrast, another operator in the group may seem slow by comparison to the first man, yet there may be a vast difference in their productivity. The second man moves in a steady, unhurried, smooth, systematic fashion, makes no false movements, makes every movement count and, with his superior skill, he produces a great deal more than the first man. This case of effectiveness of the second man is harder to "see" and to rate than the discounting of the first man's efforts.

Sometimes occasional bursts of speed on the operator's part have a tendency to influence ratings. We recall one green T.S.M. who was badly fooled by a clever bench molder in an iron foundry. The molder was an 80 to 85 worker but, while he was being time-studied, gave a 55 to 60 demonstration. After he had rammed up his mold, his last element was to carry the finished mold out to his floor. Although this last element was short and only a small percentage of the cycle, the molder exhibited 85 to 90 in performing it. This burst of speed caused the T.S.M. to reconsider his previously applied 55 to 60 ratings and raise them in line with the ones given to the last element, resulting in a loose standard.

As another illustration of speed and its effect, we shall assume the case of operators E and F who are both squaring up the keyways in threshing-machine engine crankshafts. Both men are using the same kind of tool equipment, including the same size hammers and chisels, and are removing the radius left in the end of the keyway by a milling cutter in a previous operation. The men are working at the same rate of speed and, so far as handling, filing, gauging, etc., their times are alike and they receive 80 ratings. The T.S.M. notes that on the element of chipping, the machinists' hammers of both men are uniformly striking about 70 blows per minute, but that there is a difference in watch readings between the two men in the completion of the chipping element. The T.S.M. decides he will count the entire amount of blows struck by each man besides posting the time differences. He draws up a work sheet which is a recapitulation of his data, somewhat as follows:

	Man E, minutes	Man F, minutes	F to E efficiency
Actual av. of watch readings	4.5	5.0	4.5/5.0 = 90%
Actual av. of chipping blows	315	360	315/360 = 87.5%

Considering E for a trial basis for the 80R., he sets up an average:

$$80 \times 90 \text{ per cent} = 72\text{R.} \qquad \text{or} \qquad \frac{72 + 70}{2} = 71 \text{ average}$$

$$80 \times 87.5 \text{ per cent} = 70\text{R.}$$

The judgment of the T.S.M. tells him that F is faster than 71R. and he therefore decides that the effect of E is better than 80R. and consequently gives him the benefit of half of the difference, $80 - 71 = 9$ points, or $4\frac{1}{2}$ points. Therefore, using E's time of 4.5 min., he solves for normal:

$$\frac{4.5 \times (4\frac{1}{2} + 80)}{60} = \frac{4.5 \times 84.5}{60} = 6.34\text{N.}$$

In the foregoing illustration, hammer blows, in addition to watch readings, were used to normalize. The element of chipping was a major part of the cycle and but little error could be toler-

ated, hence the extended figuration. Not every job offers tangible details to compute the effectiveness of speed ratings and the T.S.M. must make prolonged studies of a questionable element, try various operators on the same job, or run tests to clarify watch readings from which normals can be specified that are fair to both employer and employee.

Oftentimes ratings can be weighted from the study of waste or spoilage reports on various workmen, inspectors' reports to verify the skill factor, by the characteristics of the workmen, and by other valuable sources of information to be found in every plant.

Your foreman or one of your business associates may be an expert in judging the effectiveness of speeds on different operations. After you have explained the rating method symbols to him, his understanding and translation of them will prove of help to you. We have often found foremen who were very anxious to secure liberal standards for their operators; yet when these same foremen were asked to rate certain operators, they would invariably rate from 5 to 10 per cent too tight, *i.e.*, an operator working at 80 would be rated as 75 by the foreman.

When timing and rating the elements of a peculiar type of job, an enthusiastic foreman who knows his workmen and has a good working knowledge of rating can often be of assistance to the T.S.M. The foreman can have a list of the elements of the operation being studied and, without using a stop watch, he can silently post on his sheet his ratings of the different elements as they are completed. Afterward, the foreman's ratings can be compared with those specified by the T.S.M.

Two experienced time-study men should come within 7 per cent of each other's ratings for an operation as a whole or for any element in the cycle. The tendency for a green T.S.M. is to rate too tight. An 80 performance, as previously stated, is not a question of excessive speed but is the result of even, smooth, brisk, timesaving movements that the average skilled operator should easily and continuously demonstrate without injury to himself, material, or equipment.

Referring again to Table 2 on page 65, it is seen that the scale of ratings given has 5 point increments. Some experienced time-study men state that they can "see" finer than 5 points difference and can easily discern 2½ points between certain

ratings. Instead of writing "75 to 80R." after a watch reading, they post "75+R." which means 77.5R. and is the same as 80−R.

Besides the opportunities offered in the plant to secure rating practice by studying your own work or that of others, you can obtain further practice by making time studies of many repetitive things in your own home. Some of them are

Washing dishes	Sweeping various rooms
Making beds	Cutting grass
Raking lawn	Shoveling snow
Cleaning icebox	Washing windows
Shelling beans	Peeling fruit
Paring potatoes	Polishing furniture
Washing automobile	Sawing boards
Driving nails	Shoveling sand
Piling lumber	Stacking bricks

The first item, washing dishes, offers a nimble type of operation. Studies should be taken on one person for several nights. Request the person to work at a uniform rate of speed, but to vary the speed each night so that different nightly ratings can be prescribed. For example, one night the person being studied performs uniformly slow, the next night, consistently fast, etc. Then, after several studies have been secured from the efforts of one person, other persons should be studied on the same volume of dishwashing. This task might be split into elements as follows:

A. Remove articles to kitchen.
B. Remove scraps of food from six plates.
C. Scrape food from four large dishes.
D. Place all articles in pan.
E. Wash six glasses and place in rinsing rack.
F. Wash six each sets of silver and place in rack.
G. Wash six each sets of china and place in rack.
H. Wash tinware and place in rack.
I. Rinse contents of rack.
J. Wipe glasses.
(Add other necessary elements.)

If the reader has friends living on farms, he can obtain excellent studies on farm chores, such as

Milking cows	Pitching hay
Feeding stock	Picking fruit
Shocking corn	Hitching horses
Bedding down horses	Cleaning stalls
Husking corn	Gathering eggs
Spraying plants	Killing and dressing fowl
Shoveling grain	Digging postholes

The reader should always break down the job he is about to study into suitable elements. The elements should be clean-cut subdivisions of the whole operation and watch readings should be taken at the precise ending of each element and ratings for them entered alongside. As instructed in Chap. II, the watch should be returned to zero after each element.

The T.S.M., whether new or thoroughly experienced, must continually ask questions of himself on every element before he sets down ratings to accompany the watch readings. A few of them are

Is this a slow or nimble type of operation?
Can I honestly "see" the rate of speed?
Are the variations in my watch readings due to the nature of the work or the operators?
How much faster should the operator perform to reach 80?
How much faster could operator go to beat 80?
Is the operator suitable for the job?
Is operator in sympathy with the time study?
Is he working in a smooth, systematic, official manner?
Have I reconciled speed with effect?

Questions

1. How much faster in percentage is 80R. than 60R.?
2. Write the definition of 80 rating.
3. Write the formula for normalizing, using the symbols.
4. In applying ratings, do you allow for fatigue, etc.?
5. What is the permissible limit of error between the ratings of two experienced time-study men?

Problems

NOTE: The figuration and answers to the following problems should be solved by your slide rule.

6. Normalize the actual: 15 min. @ 70R.
7. A foreman states that in comparing two of his workers that *A* is 16 per cent faster than *B*. *B*'s record shows 69R. What is *A*'s rating?
8. Operator *C* is only 82.5 per cent as efficient as *D*, the latter having an average of 80+R. What is *C*'s actual rating?

9. A normal of .15 min. is allowed for an element. What is the actual time that a 75R. operator will require for the element?

10. A girl operator on twisting frames in a cotton mill has an average of 78 for her rating, and her usual waste produced is negligible. One day her waste runs much higher and she is allowed only 91 per cent of her average as a penalty. What is her revised rating for that day?

11. Normalize the actuals in the following problem and give the sum of the normals:

Element A = .98 min. @ 90R.
Element B = .32 min. @ 75R.
Element C = 1.88 min. @ 45R.
Element D = 1.02 min. @ 80R.

12. What is the normal time required for an average man carrying a load of 3 lb. to walk 460 ft.? (Rest factor not considered.)

13. A man who usually walks at a normal rate of speed in order to catch his train, finds, one morning, that he must walk faster in order to get to the station in time. Accordingly, he walks the 3 blocks in 1.9 min. Assuming each block is 250 ft. long, what is the man's rating on the morning of his faster effort?

14. A bench worker is so skilled in balancing small motor commutator shafts that 15 per cent is added to the normal to compensate for skill. The operator averages 2.85 min. per shaft and was given a rating of 75R. What is the allowed normal per shaft?

15. A T.S.M. studies a job of such character that there should be but little difference in the watch readings on each element. However, operator J, by his erratic speeds, causes variations in readings in each element and the T.S.M. rates him on 3 cycles and studies operator K, who gives him a more even study on the same amount of cycles on the same job. The T.S.M. is able to rate so closely that for the total of the element normals, he takes an average of both J and K's normals. Work out the average total normals from the following:

Step 1 for Operator J

A. Watch readings, 1.61 min. @ 70R.; 1.40 min. @ 80R.; 2.25 min. @ 50R.
B. Watch readings, 2.50 min. @ 70R.; 2.75 min. @ 65R.; 3.55 min. @ 50R.
C. Watch readings, .48 min. @ 75R.; .45 min. @ 80R.; .90 min. @ 40R.

(NOTE: The average of the three watch readings in each element should be used in arriving at total.)

The T.S.M. now studies operator K, who demonstrates an even performance and consequently, receives only one rating for each element. Therefore, the watch readings in each element are averaged before being normalized:

Step 2 for Operator K

A. Watch readings, 1.40 min.; 1.43 min.; 1.42 @ 80R. average =
B. Watch readings, 2.18 min.; 2.20 min.; 2.22 @ 80R. average =
C. Watch readings, .43 min.; .46 min.; .44 @ 80R. average = ______

Total of normals =

Step 3

Average of J and K = ?

16. The length of a cycle is 1 hr., 5 min., 30 sec. It was given a rating of 65R. What is the normal cycle in decimal minutes?

17. Two time-study men are asked to specify a rating for an operator. One T.S.M. specifies 50R., and the other 40R. Could these ratings be averaged and why?

18. A factory clerk was time-studied and it was found that he worked at a normal rate to take care of his duties during his 8-hr. day. How much spare time would he have if he completed his day's work at 80R.?

19. After studying 28 operators in a department, the T.S.M. rates each man for his average 8-hr. daily performance and decides that a total of 24 men, if all worked at 75R., could do the same amount of work as the 28 men are now doing. Prove the correctness of the T.S.M.'s survey and recommendations from the following data:

5 men now working @ 60R.
5 men now working @ 50R.
8 men now working @ 75R.
10 men now working @ 65R.
28 total men.

20. Referring to Prob. 19 above, what saving in percentage is there when 24 men do the work of 28 men?

Answers to Questions

1. An 80 rating is 33⅓ per cent faster than a 60 rating.

2. A skilled workman, producing excellent work under average conditions at a brisk, maintainable rate of speed.

3. N. = $A \times R/60$.

4. No. All proper allowances are later added.

5. The ratings of two experienced time-study men should not exceed 7 per cent variance.

Answers to Problems

6. N. = 17.5 min.

7. A = 69R. × 1.16 = 80R.

8. C = 82.5 per cent × 80+R. = .825 × 82.5R. = 68R.

9.

C	Set 75R. on	Under 60R.	
D	.15 min.	Read .12 min.	At 75R. will require .12 min.

10. .91 × 78 = 71R.

11.

Element A	.98 min.	@ 90R.	= 1.47 min. N.
Element B	.32	@ 75R.	= .40 min. N.
Element C	1.88	@ 45R.	= 1.41 min. N.
Element D	1.02	@ 80R.	= 1.36 min. N.
		Total	= 4.64 min. N.

12. $.00368 \times 460 = 1.69$ min. N.

13. The man is required to walk $3 \times 250 = 750$ ft. to his train. Walking normally, he walks 750 ft. in $.00368 \times 750 = 2.76$ min. Since, on the morning in question, he walked the usual distance in 1.9 min., the slide rule shows:

C	Set 1.9 min. on	Under 60R.
D	2.76 min.	Read 87R.

Ans. 87R.

14. $\dfrac{2.85 \times 75\text{R.}}{60} \times 1.15 = 4.10$ min. allowed normal.

15. Step 1 for Operator *J*

A. 1.61 @ 70R. = 1.88N.; 1.40 @ 80R. = 1.87N.;
2.25 @ 50R. = 1.88N.

$$\frac{1.88 + 1.87 + 1.88}{3} = 1.88 \text{ min. Av. N.}$$

B. 2.50 @ 70R. = 2.92N.; 2.75 @ 65R. = 2.98N.;
3.55 @ 50R. = 2.96N.

$$\frac{2.92 + 2.98 + 2.96}{3} = 2.95 \text{ min. Av. N.}$$

C. .48 @ 75R. = .60N.; .45 @ 80R. = .60N.;
.90 @ 40R. = .60N.

$$\frac{.60 + .60 + .60}{3} = \underline{.60 \text{ min. Av. N.}}$$

$$\text{Total} = 5.43 \text{ min. Av. N.}$$

Step 2 for Operator *K*

A. $1.40; 1.43; 1.42 = \dfrac{1.40 + 1.43 + 1.42}{3}$ @ 80R. = 1.89 Av. N.

B. $2.18; 2.20; 2.22 = \dfrac{2.18 + 2.20 + 2.22}{3}$ @ 80R. = 2.93 Av. N.

C. $.43;\ .46;\ .44 = \dfrac{.43 + .46 + .44}{3}$ @ 80R. = $\underline{.59}$ Av. N.

Total = 5.41 Av. N.

Step 3

$$\frac{5.43 + 5.41}{2} = 5.42 \text{ average normal}$$

16. 1 hr. = 3,600 sec.
5 min. = 300 sec. 3,930/60 = 65.5 min. @ 65R. = 71.0 min. N.
30 sec. = $\underline{30}$ sec.
3,930

17. No, because $^{40}\!/_{50}$ = 80 per cent efficiency; should be 93 per cent or more. On page 76, it was stated that two experienced time-study men should come within 7 per cent of each other's ratings.

18. 8 hr. = 8 × 60 = 480 work minutes in the day
480 × 60/80 = 360 required minutes @ 80R.
120 min. or 2 hr. spare time.

19. Present performance of 28 men:

$$\frac{5 \text{ men} \times 60\text{R.} \times 60 \text{ min. per hr.} \times 8 \text{ hr.}}{60} = 2{,}400 \text{ effective min.}$$

$$\frac{5 \text{ men} \times 50\text{R.} \times 60 \text{ min. per hr.} \times 8 \text{ hr.}}{60} = 2{,}000 \text{ effective min.}$$

$$\frac{8 \text{ men} \times 75\text{R.} \times 60 \text{ min. per hr.} \times 8 \text{ hr.}}{60} = 4{,}800 \text{ effective min.}$$

$$\frac{10 \text{ men} \times 65\text{R.} \times 60 \text{ min. per hr.} \times 8 \text{ hr.}}{60} = 5{,}200 \text{ effective min.}$$

Total = 14,400 effective min.

Proposed performance of 24 men:

$$\frac{24 \text{ men} \times 75\text{R.} \times 60 \text{ min. per hr.} \times 8 \text{ hr.}}{60} = 14{,}400 \text{ min.}$$

20. Present amount of operators = 28
Proposed amount of operators = 24
Proposed saving of operators 4

$\frac{4}{28}$ = 14.3 per cent saving.

Chapter V

An attempt to cover in written form the countless problems met in human engineering and the ideal solutions for them is almost an impossible undertaking because each has aspects subject to individual treatment. That treatment cannot be standardized since no two persons respond alike in human relationships. Thus, both problems and the human element involved present a combination of peculiar circumstances which escape exact classification and treatment.

In view of this, Chap. V can do no more than deal briefly with some of the general labor situations met in time-study work. The list of 77 characteristics should be of help in the task of classifying jobs and men.

Many time-study men have advanced rapidly to higher positions in management not because of their knowledge of the mechanics of time-measurement principles but by reason of their continued success in handling problems in human engineering. They know how to sell, and keep sold, the things best for industrial operations.

CHAPTER V

ANALYSIS OF LABOR

The rating method finds its chief outlet through labor analysis. The understanding and direction of labor is often a complex problem. The T.S.M. is almost continually associated with labor and, consequently, must know a great deal about this most fascinating side of time study.

Although this has been called the "machine age," the total number of wage earners continues to increase each year, which seems to refute the idea that the machine is displacing the man. Modern machinery may directly affect many workers, but these workers are benefited indirectly by the broadening fields of endeavor created by the machine. These broadening fields must be serviced by the yearly increasing numbers of wage earners who, in turn, are rewarded for their efforts through the medium of time study, which sets the task paid for by modern incentive wage plans.

We shall not go into the matter of why incentive plans are necessary or what values may be obtained from them. Instead, we shall assume that a satisfactory wage plan is already working, or will be placed in use; one which is attractive to labor and understood by the reader. We shall further assume that the reader is called upon to analyze labor in a factory whose entire personnel is unknown to him.

Efficient manufacturing methods call for subdividing the product to be made into divisions, processes, and operations. The operations require different classes of labor possessing the mental or physical fitness, skill, or other qualifications necessary for an economic production from the operations. To this end, operators are employed or trained for the tasks for which they are best suited.

The selection of operators for given tasks is not within the province of the T.S.M. The placing of the proper operator on a job to be studied is a part of the foreman's duties. However, if

it is found that an operator is not suitable for the job being timed and, as a result, the analysis and rating become involved, the T.S.M. can properly request from the foreman the services of another operator.

All approaches to labor should be made through the foreman. If time-study work is new to the department, the foreman explains to the workers about the studies to be undertaken and requests their cooperation in helping the T.S.M. arrive at accurate standards in the least possible time. Since the T.S.M. has no control over labor, he must have the proper contact if his wishes are to be carried out. Every operator will respond to contact, and the T.S.M. should pride himself upon his ability to deal diplomatically with difficult types of operators in order to bring about the desired demonstrations without assistance from the foreman.

It is of prime importance that the T.S.M. have friendly business relations with the foreman. Also, he must learn much of the foreman's capacity. It can be stated that the conduct and performance of the operators as a whole are reflected in the type of foreman in charge of them. If a casual survey reveals conditions in a department where many of the workers are lazy, loud-talking, insolent, etc., it can generally be traced to lack of discipline and leadership on the part of the foreman. Since the foreman is a barometer of conditions in a department, it is advisable to make contact first with the foreman before dealing directly with labor.

There are various kinds of foremen. Many are ready to cooperate in every way to bring about improved conditions. Others are obstinate and cannot see how any changes for betterment can be made. Between these two extremes, there are many classifications that must be recognized and handled in an appropriate manner.

The hardest type of foreman to handle is the obstinate one. If allowed his own way, he is agreeable and seemingly friendly, but when opposed, he will seldom lend wholehearted support to a time-study suggestion that may appear revolutionary to him. This type of foreman cannot be driven into a radical change of thought by pressure; it serves only to antagonize him. He can be gently led but not forced into conclusions. Spirited arguments are useless in attempting to alter the vision of an obstinate

foreman who has only one perspective. Your own experience prompts the belief that an argument leaves each party to the controversy more strongly convinced than ever that he is right. This is unfailingly true where both of the participants are of the obstinate type. A T.S.M. can handle obstinacy on the part of a foreman or operator in several ways. Persuasion is necessary, but it must be done in a calm, tactful manner without arousing opposition. Logical reason is often generated in the minds of obstinate persons by skillful suggestion. In fact, suggestions that are conveyed in a subtle way often cause a complete reversal of opinion. These same suggestions may later be presented to the T.S.M. as being original with the speaker, but the T.S.M. should quietly allow him to assume credit for the idea.

Foremen who do not know the advantages secured from time study entertain conscientious beliefs that the work under their supervision is not subject to study and standardization. They are willing to assist in every way despite the element of doubt as to the maintenance of quality, precision, volume of production, and ideal conditions which they believe exist in their departments. Their reluctance to change conditions is not due to obstinacy, rebellion, or lack of faith in the T.S.M. but accrues from the feeling that their work is too complex to standardize successfully through time study. This class of foremen represents the average type found in factories. They are cautious but willing to be "shown," and after a few of the initial studies have been proved to them, they become enthusiastic endorsers of the T.S.M.

The best type of foreman, found in smaller number in each plant, is the one who is a hard worker, has complete grasp of his job, is loyal to his superiors and his men, and is anxious for improvement in his work. Any doubts he may have as to whether time study will reveal any of his weaknesses or oversights are quickly dispelled by his realization that a good T.S.M. has received a peculiar training that enables him to analyze, rate, and time operations better then he, the foreman, could possibly do without the equivalent training.

In order to learn something of the extent of a foreman's capacity and how much he can be depended on for constructive help, the T.S.M. should encourage the foreman to talk about conditions in the department, the characteristics of the various

operators, significant items of interest pertaining to the work to be studied, or any other data that he may volunteer.

Most people cover their true selves with a thin surface or veneer which is presented to strangers or casual acquaintances. This superficial surface may be used to cover embarrassment, timidity, inferiority, or many other characteristics. Capable employment officials state that they allow an applicant for a position to talk freely about himself and finally the surface is penetrated and the true nature or capacity of the person reveals itself. The T.S.M. should induce a foreman to talk so freely about himself and his work that all barriers of reserve are finally lowered and the real traits of the foreman become manifest.

Adroit questions can be asked of the foreman and his answers to them often used as a gauge for his general intelligence and ability. For example: if he is asked how many male and female employees are under his control and he promptly specifies an accurate total without recourse to the slow process of counting off each employee on his finger tips, he can receive credit for that detail. When asked to tell the average percentage of waste in his department and he quickly replies without references to daily records, this ability partly indicates his interest in his job. Many other questions can be asked of him in regard to amounts of absentees, total number of machines in a room, what he considers his most difficult or easiest operations, manufacturing limits on particular pieces of work, speeds of certain machines, tool expense, his best operators, and dozens of other items. His reactions and responses to your questions and their accuracy, which is later checked, can partly be used as credit in his behalf.

Many foremen keep elaborate records of their work, and the time spent in personally maintaining them gives rise to the thought that they are applying themselves as clerks rather than supervisors. Thus, if responses to general questions are made from constant references to card indexes, the T.S.M. must find out whether the foreman is stimulated into action over any fluctuations that occur in the data, and if his available time as supervisor allows him sufficient time to correct faulty conditions. A department should have adequate records kept by a factory clerk who advises the foreman concerning variations that require action. Proper records that treat not only of past performance, but of possible future trends as well, offer valuable information

to the T.S.M. for counts, variables, incidentals,[1] etc. Besides the knowledge to be gained from inquiries relating to the work in a department, knowledge of the foreman's personal traits and mechanical ability is essential in order to weigh comments made by him.

TABLE 3

1. Accuracy	39. Leadership
2. Aggressiveness	40. Loyalty
3. Alertness	41. Master of detail
4. Ambition	42. Mechanical ability
5. Analysis	43. Mental energy
6. Carefulness	44. Methodical
7. Common sense	45. Obedience
8. Concentration	46. Open-mindedness
9. Conservatism	47. Optimism
10. Constructive ability	48. Orderliness
11. Cooperativeness	49. Organizing power
12. Courage	50. Originality
13. Courtesy	51. Patience
14. Decisiveness	52. Perception
15. Discipline	53. Perseverance
16. Diplomacy	54. Personality
17. Directive ability	55. Physical capacity
18. Driving power	56. Planning ability
19. Economy	57. Power of sympathy
20. Efficiency	58. Practical ability
21. Effort	59. Pride of workmanship
22. Endurance	60. Proper conduct
23. Enthusiasm	61. Prudence
24. Executive ability	62. Punctuality
25. Experience	63. Quickness of movement
26. Fairness	64. Resourcefulness
27. Faith	65. Reliability of performance
28. Friendliness	66. Salesmanship
29. Good memory	67. Self-confidence
30. Good mixer with labor	68. Self-control
31. Honesty	69. Sense of responsibility
32. Imagination	70. Skill
33. Impartiality	71. Tactfulness
34. Instructive ability	72. Temperament
35. Intelligence	73. Tenacity
36. Judgment	74. Thoroughness
37. Justice	75. Truthfulness
38. Keen observation	76. Trustworthiness

77. Understanding of human nature

[1] See Chap. X.

Table 3 lists many characteristics, several of which will be found in every foreman. We hesitate to suggest that all of them are necessary for successful foremanship. Any individual possessing all of them in high degrees would be too busy as chairman of the board of large industries to find time to act as a foreman. However, the T.S.M. can make use of the list in either a direct or indirect way in order to get a line on the type of foreman who is supervising labor.

After contact has been made with the foreman, the next step is the analysis of the workers on each job studied. Labor, whether male or female, is divided into three classes: common, semiskilled, and skilled. Manufacturing operations require the use of one of the three classes of labor. Workmen in each class should have one or many of the characteristics in the foregoing table to complete successfully the operations.

No two men can be handled alike. One man reacts favorably to one appeal or command, whereas the next man responds best to an entirely different manner of approach. The mission of the T.S.M. is to study each operation in the department. In so doing, he generally meets all of the three classes of workers. The T.S.M. is selling a thing that is valuable to labor. The story to be told is a comparatively simple one. It is explained in the language best understood by the worker. It should never be explained in the hurried, high-powered fashion employed by the previously mentioned street-corner salesman. The T.S.M. requests each worker to give him an honest effort so that the ratings will make possible a correct standard. He further explains that any foreign movements made by the operator are not considered, because the watch is stopped during such maneuvers, and that the constant starting and stopping of the watch might unintentionally result in a tight, rather than a loose standard.

The T.S.M. should always make plain the fact that *he is only finding out how much work should be produced per day by a normal man on the operation and that the money paid for it is entirely outside of his jurisdiction because the rate of wages paid to labor is a management specification.* A worker should never be sold from the money angle, *i.e.*, how much wages can be obtained by diligent effort. It is not within the scope of duties of the T.S.M. to talk of money to be made on each operation or to offer it as a bait for

cooperation. Instead, the worker should be told that he should do his job well before and after the time allowances are established and that the money paid to him is a reward for his extra effort. Also, it should be pointed out that a continued effort will do more than anything else to obtain promotion later on to a better job in the plant. To emphasize this point: many of the foreign-born parents who have children working in factories or mills insist that all pay envelopes be brought home unopened. One of the parents opens all envelopes and, irrespective of how much money may be in the envelope, only a fixed weekly amount is returned to the family member who earned all of it. Thus, a money appeal to workers of this kind falls on barren soil, whereas the possibility of promotion to better or easier jobs often creates an ambition that is not stimulated by the money angle.

No one objects to a specified task if rewarded for it. It is the misunderstandings and unfulfilled promises that cause resentment. From prehistoric times, man has demanded the right to food, clothing, and shelter, and, although the original system of barter has changed, nevertheless, modern man still insists on these cardinal requirements. The T.S.M. is the agent through whom these and other things are obtained by labor; therefore he should recognize the magnitude of his time-study work and the fact that it must be outlined to labor in understandable and acceptable form.

It is not necessary to relate the complete story of time study to every operator in a plant. Each foreman can advise the T.S.M. of representative operators in each department who may be told the story and who will understood it. These men not only pass on the information to their less intelligent fellow workers but help to build up the enthusiasm that must be created by the T.S.M. After a few standards have been demonstrated, the successful results are more impressive than anything the T.S.M. can say. As the operators under other foremen are applied, the T.S.M. finds that his story has preceded him in other departments and that his time is occupied more with answering various questions than with a recital of the same story he told in the first department. Any statements made or instructions given by a T.S.M. must at all times be so definite and clean-cut that nothing about them can be misleading or later distorted.

The opportunity to tell his story and institute his contact is offered to the T.S.M. at the time he requests the preliminary information from the operator whose job is to be analyzed and timed. This information covers the operator's name, clock number, the part number, name and operation of the job, etc. For the same reasons as those outlined for the foreman, questions should be asked of each operator in order to get him to talk. The kind of questions should be varied to suit each operator. For example, one man might be asked how long he has been on his present job; how he likes it; how much trouble he has on any part of the operation; the tool consumption per week; average amount of castings per lot; the speeds or feeds of his machine, etc. Besides showing his intelligence by his answers to questions, his conversation will, most likely, reflect some insight of traits or personal characteristics that are helpful to the T.S.M. Any grievances, fancied or real, can be analyzed and perhaps corrected. The dissatisfaction an operator may express over his job usually emanates from one or more of the following reasons:

Low wages.
Long hours.
Inequalities of wages.
Poor location of plant.
Bad working conditions.
Inability to see a future.
Hot temper and independence.
Wanderlust regardless of future.
Dislike for particular kind of work.
Inability to get along with fellow workers.

Whenever any of the foregoing reasons are advanced, the T.S.M. can prevail on the operator to suspend judgment or feeling about his job until after the job has been placed on standard which should then alter the conditions causing complaint. Knowing something about an operator helps in the task of specifying ratings. The operators that are desirous of helping all they can by honest execution of their duties are quickly identified and little, if any, missionary work is necessary for them.

One of the hardest types of workers to deal with is common labor, particularly where the workers are foreign-born and uneducated. Not only must the program of time study be outlined to them in the simplest form of word pictures, but also in such portrayal as to disarm any criticism that may later arise over

their protested misunderstandings of the program. For some reason or other, many foreigners on common labor jobs seem to find it convenient to misunderstand the T.S.M. Whether this is born of a natural distrust of overtures made to them is subject to debate. Whenever the T.S.M. feels that his story is not registering, an interpreter should be used to make sure the intended program is understood.

As a general thing, intelligent workers respond best to the T.S.M. Their quick perception of the rating principles dispels any preconceived feeling that their speeds or efforts should be retarded while being studied. Furthermore, when it is explained that all allowances for fatigue, delays, etc., are built into each standard and that all items and figurations are at any time available for their examination, very little watch stoppings, adjustments, and reconciliations are necessary. The T.S.M. will occasionally find that a skilled worker who has responded to contact will work at such a fast pace that he must be slowed down in order to fall within the rating range the T.S.M. feels he is best qualified to observe.

We again quote a principle outlined in a previous chapter: "The effectiveness of labor is determined by the personal characteristics of the worker. It includes such things as temperament, skill, effort, intelligence, experience, physical strength, endurance, and resourcefulness." These eight basic items cover one or more qualifications that may be demanded of an operator regardless of the classification of the job. Any of these basic items can be amplified by reference to Table 3 which can apply, in part, to workers in any of the three classes.

The next step, after becoming acquainted with labor, is to analyze the job to be studied in order to learn what characteristics are expected of a suitable operator and if the present operator on the job fills the desired specifications. One should not try to fit square pegs into round holes, nor should one assign an obviously improper operator to tasks for which he is unsuited. Conclusions regarding the aptitude of a worker cannot be drawn from casual inspection. One man may be normally calm but is nervous because he is being observed. Another man might ordinarily work in a smooth, systematic manner and, although desirous of cooperating, he may, because of mental disturbance, perform in an entirely different fashion. The T.S.M. must be

able to distinguish these differentials and overcome them. A naturally nervous and quick-tempered worker should never be placed on a job that excites his unfavorable tendencies. The T.S.M. can, no doubt, study such a misfit and, by proper rating, arrive at an equitable standard. However, this same operator, if left on the job, may cause many excess costs, especially if the standard calls for an appreciable increase in daily output. The importance of recognizing improper operators working on jobs unsuited to them, and thereby necessitating added attention to the ratings, will be exemplified in the two examples which follow:

Example 1: The speed of a power conveyor belt is increased. At the delivery end of the belt, a man is stationed to remove the finished units and place them on a near-by truck. The units are heavy and fragile and although they are being delivered by belt to him at a brisk rate, he must handle each one carefully. The T.S.M. refers to Table 3 and specifies the operator-requirements to be

6. Carefulness
22. Endurance
53. Perseverance
55. Physical capacity
63. Quickness of movement
65. Reliability of performance

Upon analysis, the man is found to be too light for the job and although he is capable of quick movements, he is too lazy to have reliability of performance without constant supervision. The T.S.M. brings these negative traits to the attention of the foreman, because valuable time is lost in attempting to study this misfit, not to mention the probable damage to the fragile units.

Example 2: Several operators are each assembling engines. Some of the details of their work cannot be thoroughly inspected. The qualities required for a suitable type of operator for this job are

1. Accuracy
6. Carefulness
21. Effort
25. Experience
36. Judgment
41. Master of detail
42. Mechanical ability
44. Methodical
48. Orderliness
51. Patience
55. Physical capacity
59. Pride of workmanship
65. Reliability of performance
69. Sense of responsibility
70. Skill
74. Thoroughness
76. Trustworthiness

After observing each operator, the T.S.M. decides that none of them possesses all of the total qualities and recommends that an instructor be placed on the assembly job for a few days to work with the different assemblers in order to prepare them for time study. When asked by the foreman for the reason for this request, the T.S.M. complies as follows:

Two men are new on the job. None of the six men attempts any regular procedure in the completion of work.

One man, although fast, rehandles unnecessarily almost every assembly part.

Three men are clumsy and untidy about their benches, which retards smooth assembly.

All six men have different ideas about scraping in bearings, and this causes variation in the watch readings.

One man insists on filing a previously filed surface that has passed inspection.

All six men faithfully tighten down a bracket that is later removed before block test.

Reaming of camshaft bearing is not necessary, because all have previously been reamed and have passed inspection.

The contact with labor does not end upon completion of time studies. When the piecework prices or standards have been put into effect, the T.S.M. must prove to the operators that the tasks set are fair and can be met. He must also satisfy the foreman and inspectors that the quality and precision can be consistently maintained and that the job as a whole is satisfactory. Oftentimes standards will call for as high as 500 per cent more production than was formerly considered a good day's work. These cases are common and the reactions on the part of the foreman and operators require the T.S.M. to display a quality of leadership necessary for such situations. The T.S.M. must take the attitude that if the standards called for 5,000 per cent increase, he stands ready to prove it. He should be right before making any claims, but after he has gone over his data and has taken "spot checks" to prove his contentions, he should take a firm stand.

When time studies have been proved and the foreman, inspectors, and operators are satisfied, the main duty of the T.S.M. ends. The foreman then takes over the responsibility for the standards and their continued success. However, the T.S.M. must apportion a part of his daily time to keeping in touch

with the operators and jobs placed on standard. He must allocate time to consult with the foreman and inspectors and time to look over factory records each day to make sure that standards are not violated.

If not properly supervised, a few operators allow their higher wage ambitions to jeopardize precision and quality of product. There are times when wild rumors, started by some irresponsible individual, cause the morale to sag. A slow operator might protest that his standard is too tight and his complaints may influence workers near him. An instance is recalled in a radiator foundry core room; several coremakers were all working on dry-sand radiator cores whose various lengths, widths, and contours were so graduated in size as to permit of easy time study. The amount of effort was relative to each size of core and, by reason of this, studies were made on the smallest and largest sizes, together with a few intermediate sizes and a curve was prepared which prescribed relative standards for each size of core. Thus, if one standard was correct, all of them were correct; if one was wrong, all were wrong. After the standards were applied, the records showed the coremakers all producing according to standards except for one 32-by-5-in. size. For weeks the production of this size was low, although different coremakers were placed on it. Finally, the foreman suggested a recheck by the T.S.M. This was done and the standard was found to be correct. After the T.S.M. left the core room, the foreman decided that the job in question was a victim of a mental state of mind, so he advised the coremakers that the recheck of the standard of the core size in dispute was not only correct but that he thought it was a little loose. From that time on the 32-by-5-in. core was considered the "easy job" in the core room.

The most serious kind of rumor that is periodically started in a plant is to the effect that all standards will soon be cut. Time studies correctly taken will produce standards that can be guaranteed against cut. This rule is outlined in a subsequent chapter. Many operations in factories have been cut every so often through a period of years. This frequent cutting of rates (aside from the law of supply and demand which affects labor) is the chief reason for any animosity labor holds toward the plant officials. When the time allowances covered by standards are guaranteed, a different atmosphere prevails. The

periodical slashing of rates or standards because of faulty time studies is not only a costly practice but destroys any hope of enjoying the desired harmony so essential in organizations.

One of the last things a T.S.M. should recommend is the discharge of an operator. If mentally or physically unfit, an operator should be tried on various jobs until one is found suitable for him. Workers who are troublemakers can be cured of their proclivities by being transferred to jobs so distasteful to them that, after a short period of time, they are willing to revise their tendencies.

Man efficiency is today of far greater importance than the further development of efficiency in machinery. The T.S.M. is doing his part in bringing about the increased efficiency in man.

Questions

1. Through whom is the first approach to labor made?

2. Why should a foreman feel free from the thought that a T.S.M. might reveal the foreman's inefficiency?

3. A foreman in charge of a department has a type of work that allows him but little leisure. To take care of his position successfully, he must be able to handle his men who are all skilled mechanics, inclined to be lazy, temperamental, yet who respond to individual treatment under constant supervision. The foreman does most of the inspection work because the department is too small to warrant the services of a regular inspector. The work, made in large quantities, is of accurate and delicate construction and consists of materials that are too costly to permit of much waste. Using Table 3, list at least 40 qualities out of a minimum of 50 the foreman must have in order to handle successfully the work and his men.

4. Name the classes of labor considered in this chapter.

5. Should the money angle ever be used to encourage an operator's performance?

6. Write the eight basic items that determine the effectiveness of labor.

7. What disposition should be made of mentally or physically subnormal operators who may be assigned to jobs not suitable for them?

Problems

8. The office records show manufacturing costs to be

1. Materials	$3,000
2. Direct labor	900
3. Indirect labor	2,100
Total manufacturing costs	$6,000

What is the percentage of each of the three items to the total manufacturing costs?

9. The following month after an application of standards was made, the office accountants computed that the old costs of $1,800 had dropped to $850; that the production had speeded up from 250 units per day to 450 per day and that only 10 men are on the job instead of 17 men.

a. What is the per cent saving in costs?

b. What is the per cent increase in production?

c. What is the per cent reduction in personnel?

10. As a result of installing an incentive plan for the indirect workers in a large plant, 3,250 indirect workers now do the work of 5,500. What is the percentage of reduction?

Answers to Questions

1. All approaches to labor are, at all times, made through the foreman in charge of it.

2. Because the T.S.M., although not an expert on the task set before him, can, as a result of his peculiar training, analyze, rate, time, and specify all correct time allowances, from which standards can be established. Even though the foreman may be highly intelligent and an expert on his job, he cannot build accurate standards without the equivalent time-study training.

NOTE: The reader will find that this answer will be given many times in the course of his career.

3.
1. Accuracy
3. Alertness
6. Carefulness
7. Common sense
8. Concentration
11. Cooperativeness
13. Courtesy
14. Decisiveness
15. Discipline
16. Diplomacy
17. Directive ability
19. Economy
21. Effort
22. Endurance
23. Enthusiasm
24. Executive ability
25. Experience
26. Fairness
28. Friendliness
30. Good mixer with labor
33. Impartiality
35. Intelligence
36. Judgment
37. Justice
38. Keen observation
39. Leadership
41. Master of detail
42. Mechanical ability
46. Open-mindedness
48. Orderliness
49. Organizing power
51. Patience
53. Perseverance
54. Personality
55. Physical capacity
56. Planning ability
59. Pride of workmanship
60. Proper conduct
63. Quickness of movement
65. Reliability of performance
66. Salesmanship
67. Self-confidence
68. Self-control
69. Sense of responsibility
70. Skill
71. Tactfulness
73. Tenacity
74. Thoroughness
76. Trustworthiness
77. Understanding of human nature

4. Common, semiskilled, and skilled labor.

5. No. The T.S.M. is primarily interested in production volume and not directly concerned with wages paid for work produced. His task of securing the required output is sometimes quite hard and it becomes much harder if the issue is further obscured by discussions of wage scales.

6. Temperament, skill, effort, intelligence, experience, physical strength, endurance, and resourcefulness.

7. Subnormal operators should be transferred to other tasks in the plant that are suitable for them. These tasks may be adequate for subnormal mental and physical ability, or may impose penalties for wrong mental attitudes. Recalcitrant workers may often be cured of their distorted viewpoints by transferring them to distasteful tasks and advising them that they will remain on them until their views are changed. Modern industry should be slow to discharge employees until a thorough study has been made of their shortcomings. The T.S.M. should recommend a transfer of an unsatisfactory worker rather than his discharge from the plant.

8.

1. Materials	$3,000	3,000/6,000 =	50 per cent
2. Direct labor	900	900/6,000 =	15 per cent
3. Indirect labor	2,100	2,100/6,000 =	35 per cent
Total manufacturing costs	$6,000		100 per cent

9. *a.* $\dfrac{\$1{,}800 - \$850}{\$1{,}800} = 52.8$ per cent saving in costs

b. $\dfrac{450 - 250}{250} = 80$ per cent increase in production

c. $\dfrac{17 - 10}{17} = 41.2$ per cent reduction in personnel

10. $\dfrac{5{,}500 - 3{,}250}{5{,}500} = 41$ per cent reduction in indirect workers

Chapter VI

This chapter takes up the subject of breaking down work elements for the purpose of analysis and time measurement. The questionnaire form for job analysis is a convenient method of arriving at the facts necessary for a thorough appraisal of materials, machines, methods, and surrounding conditions. Therefore, we have listed many points of inquiry which the T.S.M. may apply to his task to insure coverage of the job's important phases. The questions in Chap. VI are by no means complete. The T.S.M. should compile his own suitable questionnaires most applicable to his work.

Your full attention is directed to Figs. 3 and 4, which show graphically machine cycles and how they might be shortened by giving consideration to Externals. The External principle is not only of importance to single-machine manipulation but is extremely valuable for the analysis of like and unlike machine operations to be performed in combination by one workman.

CHAPTER VI

ANALYSIS OF OPERATION AND ESTABLISHMENT OF ELEMENTS

Having determined a value for the operators as outlined in Chap. V the T.S.M. now turns his attention to a fuller consideration of the job itself. He must acquaint himself with all direct or indirect details connected with the operation before he can start his studies.

Before the services of the T.S.M. are requested, the job to be analyzed and studied should be running in the correct manner. Thus, if a job is "tuned up" by the foreman and production engineers in advance of the arrival of the T.S.M., several hours per week of the latter's time can be saved. Many plant officials have the mistaken idea that a T.S.M. is an expert process or methods engineer on any job he studies and that he can successfully dictate ways and means of improving every operation regardless of its nature. Often the T.S.M. is an expert on the type of work he is to study, and any radical changes he may make to establish operations on an economical basis before timing are a direct reflection on the foreman. If an operation is found to be in poor working condition and perhaps to have been that way for a long period, the management should lose no time in asking why such a waste of time and money was allowed to continue without recognition and correction. There is less possibility of error in standards if every operation receives careful attention on the part of the foreman and engineers before time-study observations are begun.

Irrespective of the source of data obtained, the T.S.M. should always check their accuracy; he should take nothing for granted. If he builds standards on the premise of some other person's data which are later found to be wrong, the indictment is against the T.S.M. and not against the one whose unchecked data were accepted.

The first analysis of an operation starts with the examination of the material being worked on. The best practice is to start

on the first operation, because a full knowledge can thereby be gained of the raw material which is to be transformed in the first and also the succeeding operations in the process.

The specifications for the raw material should be digested to learn of all salient points concerning it. Numerous questions regarding the material should be asked of the foreman, the inspectors, and others. A few items are given here covering some of the general information necessary before studies can be started:

What are the official specifications of the raw material?

Is the material purchased in large or small lots?

Is the material thoroughly inspected before acceptance?

What are the tolerances allowed for variations from the official specifications?

What quantity, and why, is any material rejected and sent back to the source of supply?

What is the average amount of material per production lot released at a time to the shop?

How is the material delivered to and removed from each operation?

Is the material placed in the best location at each operation for the convenience of the operator?

What relative importance does each operation bear to the entire process?

Is the material officially inspected between operations?

What are the permissible limits of variation allowed to the material on each operation?

Is quality influenced by the operator's skill or attention to his work?

What is the percentage of waste or spoilage occurring at each operation?

Is waste primarily the fault of the operator or the machine?

What percentage of material, although not spoiled, is returned to an operation for rework?

Are unnecessary limits prescribed for the material on some unimportant operation?

Close attention to material tolerances during manufacturing processes often results in information that yields large savings. A case of this kind occurred in the grinding department of a truck plant. A hardened disk used in big quantities required grinding on all its surfaces. The hole in each hardened disk was not only small and long but was held to close limits and, consequently, the cost of the small production obtained per hour was considered prohibitive. A study of the scrap reports showed that no disks were rejected because of lack of sufficient finish in the hole to be ground. It was also learned that an unusual amount of finish had been specified for the rough hole size in order to take care of a previous turret-lathe operation. Upon further investigation, it

was found that the turret-lathe chuck was badly worn and prevented the forging blank from running true. A new chuck was installed and less finish was left in the hole by the turret lathe, which greatly increased the production of the grinding job.

Another condition which caused material wastage and high machining costs was traced to loose flask pins in the brass foundry of a factory for flour-milling machinery. The flask pins on the snap flasks were allowed to become badly worn and out of adjustment before they were repaired. This resulted in castings of varying weights and excess material to be removed from each brass casting. When this condition in the foundry was rectified, the effect was immediately felt in the machine shop.

No matter if raw materials are made of metal, wood, fabric, paper, or any other substance, they are subject to specifications that must be recognized in time-study work. Therefore, it behooves the T.S.M. to analyze materials before further steps are taken.

Attention is now directed to the machine which has been assigned for the operation under survey. Even though the T.S.M. may have an intimate knowledge of the machine being used, he should, first of all, check it with the "book speed." This is done by referring to the catalogue or descriptive leaflet issued by the manufacturer of the machine. The specified data covering the speed of the main driving pulley, the speed of the countershaft, or the basic speed of the machine are noted and afterward checked with the machine data that have been actually found. Belt widths should be checked, together with friction disks, clutches, or any other part of the machine which might cause a leakage of power. It is surprising how many machines will be found that are not running at the minimum speeds recommended by the machine-tool makers. Perhaps the machine originally ran at the correct speed, which was later altered because of some now forgotten reason, such as appropriation of the driving pulley for another machine, former use of some harder material, etc. The T.S.M. will find that the foreman is usually unaware of the machine's present incorrect speed.

One accurate way to test the working speed of a machine to determine whether or not its belts are in good condition and of proper width and thickness is to check the revolutions per minute made by the machine when it is "cutting air," *i.e.*, when the

machine is in operation without producing work. Afterward, check the r.p.m. while the machine is pulling under the load of actual production. Any marked difference between the speeds thus found should be investigated and changed. Variations between these two checks should not exceed 5 per cent. The T.S.M. may own a speed indicator or, if not, he may use one belonging to the millwright or the foreman. All slow-moving machines should be checked by placing a chalk mark on the spindle and counting the revolutions by eye for a period of 2 min. or more. Certain types of speed indicators do not register fractional revolutions which may be quite important on very slow moving machines.

The foreman and others should be consulted about machine data. A few of the general questions to be asked are

How many machines are used for the operation under survey?

Are the machines alike as to design and performance?

If not, must certain machines in the group have special standards?

Are the machines special or universal types?

If universal, are they too large or small for the job?

What are the ages of the machines?

What is the weak point on each machine?

What periodical repairs are necessary to the machines?

Are all bearings, gibs, clutches, etc., in adjustment?

What tests have been run on the machines covering speeds, feeds, or altered performance?

Why are the present speeds and feeds considered the proper ones?

Does the operator faithfully use the speeds and feeds specified, or will he change them when standards are built and applied to the operation?

Does the machine or the operator set the pace?

If there is a variance in output, is it due to the machine or operator, or both?

What kind of accidents are suffered by the operator on the machine?

What are the safety measures taken to prevent accidents?

Does the operator set up the machine, or is it done by a setup man?

If the machine is conditioned by a setup man, what does the operator do during that setup interval?

Because of varying amounts in each shop order, should a standard be built for setup?

What preparation work is necessary to start off the job?

Does the operator clean and oil the machine and, if so, how often?

Can some of the cleaning and oiling be done while the machine is producing?

For our use, we shall confine all operations to two classes: (1) manual operations and (2) machine operations. A manual

operation is one where no power-driven machines are employed and the job is done, therefore, entirely by manual labor. This statement is modified to include power-driven hand tools such as electrically driven socket wrenches and screw drivers, air-driven hammers, chisels, riveters, electric hand drills, etc. The machine class of operation is one where a power-driven machine, assisted by the operator, performs the major part of the work.

On either manual or machine operations, there is additional knowledge to be acquired with respect to tool equipment, auxiliary duties on the part of the operator, and all general conditions that help or disturb each operation. The information sought may be:

Has the job been officially approved before the analysis is started?

Does the operation allow the operator to develop a rhythm of motion?

Is the operator performing elements that should have been done in a previous operation?

Does the operation require 100 per cent of the operator's time?

Are any of the elements ones that should be handled by indirect workers or by a cheaper type of operator?

What service does the operator require of the indirect workers?

Are materials and supplies placed conveniently at the operation?

Are all the proper tools, gauges, and fixtures in use?

Have extra tools been provided for the operation?

Are the tools sharpened by the operator or others?

Can extra tools be sharpened by the operator while the machine is in action?

How many pieces can be produced before the tool is worn out or requires sharpening?

Are tools held rigidly or positioned properly?

Upon what basis will the standard be built: on yards, pounds, pieces, etc.?

Does the operation allow a foolproof method of keeping track of the operator's output?

Having satisfied himself as to the general data surrounding the operation, the T.S.M. is now ready to break up the operation into elements. The completion of an operation requires a series of subdivisions of work or duties that must be done before the operation is finished. These subdivisions are called "elements." Regular elements are ones that occur at least once in each cycle. Incidental elements are ones that occur every few cycles, as, for example, "Try gauge every fifth casting."

Regardless of whether the operation is manual or machine, elements must be established. In manual operations, the ele-

ments are all called "External elements." In machine operations, the elements can be grouped into three fundamental divisions:

1. M.T. = Machine Time = length of time that machine is actually producing work under its own power.
2. Ext. = Externals = elements done by the operator before or after M.T.
3. Int. = Internals = elements done by the operator during M.T.

To illustrate these divisions, suppose a drill-press operation has elements as follows:

A. Pick up forging and place in jig.
B. Tighten three clamp screws and position bushing in jig.
C. Start machine, position spindle, and engage feed.
D. Drill one $1\frac{15}{64}$-in. hole.
E. Release feed, raise spindle, and stop machine.
F. Remove drill from spindle, also bushing from jig.
G. Place $1\frac{1}{4}$-in. reamer in spindle.
H. Start machine, position spindle, and engage feed.
I. Ream $1\frac{1}{4}$-in. hole.
J. File off sharp burr at edge of hole.
K. Try plug gauge in hole of previously finished forging.
L. Release feed, raise spindle, and stop machine.
M. Remove reamer from spindle and insert drill instead.
N. Remove finished forging from jig and place on table.
O. Blow out chips in jig using air hose.
P. Away with finished forging to barrel.
Q. Get next forging from truck and place on table.

Elements *A*, *B*, *C*, *E*, *F*, *G*, *H*, *L*, *M*, *N*, and *O* are Externals in the cycle because the machine is prevented from actual performance until these elements have been done by the operator. Elements *D* and *I* are machine times because the machine is actually productive. Elements *J*, *K*, *P* and *Q* are Internals and can be done by the operator while the machine times in the elements *D* and *I* are in process.

For the sake of a graphic illustration as shown in Fig. 3, all elements in the above drill-press example have been grouped into Externals, Internals, and M.T. The lengths of the heavy horizontal lines represent the sum of decimal minutes for each of the three fundamental divisions.

Referring to Fig. 3, we see that the Externals must be performed before the machine starts to produce. The sum of the

Externals and the M.T. is the cycle. Since the M.T. line is much longer than the Internals line, it is apparent that the Internals can be leisurely performed without affecting the length of the cycle. Thus, it is obvious that Internals do not influence the length of cycle.

Since the M.T. is a fixed length of time, the only means of shortening the cycle (hence increasing production per hour) is to

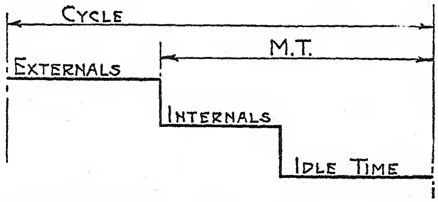

FIG. 3.—Manual elements, Machine Time, and operator's idleness grouped in a cycle.

perform one or more of the so-called Externals internally. Figure 4 shows a cycle of the foregoing graph shortened by assuming that one or more Externals were made into Internals. Otherwise the job is the same in both cases.

The shortened cycle in Fig. 4 was obtained by transferring some of the times, represented by the cross-sectioned part of the Externals, and adding them to the Internals which directly

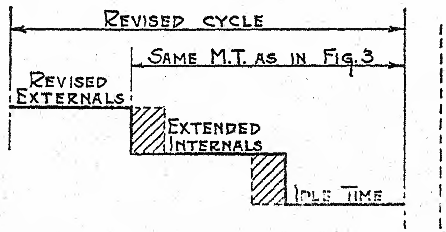

FIG. 4.—Cycle in Fig. 3 shortened by changing certain Externals to Internals.

affected the cycle length. In view of this possibility on machine operations, all External elements or their parts should be carefully analyzed and reduced to Internal elements whenever it is permissible to do so.

Operations are converted into elements for analysis, timing, and rating in order to arrive at time allowances from which standards can be prescribed. Each element is a complete story

in itself and must be treated as such. It must be analyzed, timed, and rated, and a time allowance later given to it, as though it were the only item being studied. The next element, and all the elements thereafter, must each receive this same treatment.

On the observation sheet, the sequence of elements listed should be in the order of their occurrence. Since extracts of time studies are usually typewritten and given to the operators for use as a set of instructions, the descriptions of the various elements should be very expressive. The descriptions should be written in such clear, concise terms as to leave no doubt in the mind of the reader as to the scope of each element. However, it is not necessary to expand the description of an element into a length beyond the understanding of those familiar with the job. For illustration, element *B* in the drill-press example on page 108 reads, "Tighten three clamp screws and position bushing in jig." The actual duties are considerably more than outlined in the element. The description could have been expanded to describe the element in greater detail, such as:

Hold down forging in jig with one hand.
Tighten 3/8-in. set screw by finger pressure.
Tighten top screw firmly with wrench.
Tighten side screw firmly with same wrench.
Tighten the 3/8-in. set screw firmly with wrench.
Pick up 1 15/64-in. bushing and wipe off.
Place bushing in jig leaf and engage stop pin.

As stated above, such exhaustive detail for an element as illustrated above is not necessary, because elements can be described in a much briefer manner by using shop legends in use in every plant. Sometimes there is a limit to brevity. For example, element *A* in the drill-press line-up reads, "Pick up forging and place in jig." This could be condensed to the legend, "Up forging in jig," but perhaps some of the plant officials might not understand what was meant by such a short phrase. A happy medium should be employed for legends—neither too long nor too short.

Because the stop watch is started at the beginning of each element and snapped back to zero at the end, the description of every element should be definite enough to indicate the beginning and end. Otherwise, watch readings may overlap into the

next element. If the time study is being taken on a machine operation, the different recurring noises made by the machine or tools can be used to identify the beginning or end of an element. Element *D*, "Drill one $1\frac{15}{64}$-in. hole," ends when the noise made by the action of the drill stops, thus indicating that the drill has penetrated fully and that the M.T. has ended. The T.S.M. could also have placed his hand on the drill jig or on the bearing of the main drill spindle and confirmed the end of the M.T. by the cessation of the vibration when the drill's cutting action stopped.

The noises made by finished work striking the floor, by tools being laid down, etc., can be used to signify the ending time of many elements. Basing completion of elements, wherever possible, on unmistakable sounds instead of sight allows the T.S.M. to follow the stop-watch hand as it nears its reading and to post it to his observation sheet with more freedom than when sight alone determines the finish of the element.

Where element boundaries are identified by the operator's movements, care must be exercised to catch the movement in each cycle at the precise point. Assuming an operator is required to reach 2 ft. for his next piece of work, the element does not commence when his arm is halfway to the work but starts at the instant he raises his arm preparatory to reaching. Movements can best be observed from the most judicious vantage point selected by the T.S.M. As stated in a previous chapter, the T.S.M. should never stand behind an operator. Instead, he should stand to the right or left or possibly in front of the operator. This allows the T.S.M. to face the operation and to view it over his pencil, which is poised for posting, and over the stop watch, which is ready at the top of the time-study observation board. Thus, the job, paper, and watch are in a direct line of vision and the job is being watched even though the eyes are temporarily fixed upon the paper or the stop watch.

A further reason for careful observance of element boundaries is to anticipate double movements which might cause overlapping of elements. For example, the final part of one element might cover the laying down of one tool and the next element might begin with the duty of picking up another tool. These two items of work, although in different elements, should be performed simultaneously, *i.e.*, the operator should be laying down the first

tool with one hand, and at the same instant, picking up the next tool with his other hand.

On short cycles, the elements are naturally of short length, yet the cycle should be broken down into definite elements consistent with common sense. The cycle may be too short to permit the timing of each element. If this is the case, the T.S.M. can time every other element and, afterward, time the alternate ones. It has been found that elements shorter than .04 min. are hard to observe and to post on the observation sheet. If a cycle has several elements, two of which are very short and follow each other in sequence, the alternate method should be employed for them. There are occasions on short cycles where the last element of one cycle and the first element of the next cycle are both so brief that not only is accurate timing impossible but an overlapping occurs. In a case of this kind, it is advisable to take a combined reading of the first and last elements and show the combined reading under the last element. For example:

A. Pick up piece and place on fixture (see element *C*).		
B. Bend flange to 45° angle................	.12 min. N.	
C. Remove piece and throw in barrel........	.053 min. N.	(includes *A*)
Total................................	.173 min. N.	

In the foregoing example, the watch was started at the beginning of element *C* on the previous piece of work and the watch reading was taken at the end of element *A* on the next piece. In this case only two elements were actually timed but three elements were listed on the observation sheet in order to present a full outline of the operation, which was later to be typewritten and issued to the department in the form of instruction sheets.

Long cycles may require dozens of elements for a comprehensive analysis. Perhaps each element in the total might be quite short, yet important enough to receive the same careful treatment as longer ones. Therefore, *element lengths have no fixed ratio to cycle lengths.* On long-cycle machine jobs where the operator is idle for a part of the cycle, it is good practice to establish a supplementary element to record the periods of idleness during the cycle. Although this kind of element does not appear in shop instruction write-ups, nevertheless the T.S.M. often finds it a good policy to show the idle times that have been found to reluctant operators, who are requested to operate an

additional machine or to handle a manual operation alongside their machines in order to absorb their idleness during the M.T.

Often after standards have been in satisfactory use for months, it is found that the prices quoted by competitors necessitate the lowering of operational costs. Time-study observation sheets are then brought out of the files and are carefully examined for ways and means to cheapen unit costs. Elements will be gone over with a fine-tooth comb with the view to lowering costs. An illustration of this necessity is cited in a small cotton mill. In an effort to reduce costs which were previously satisfactory, all time studies were gone over. The first regular operation in the cotton process occurred in the picker room. The finisher lapper delivered a 42-lb. cotton lap every 5 min. After weighing the lap, the operator was required to place the lap on his shoulder and walk 150 ft. to the card room, where he placed it in one of the card creels. In making this trip, he had to open and close two doors separating the two departments. Thus, to deliver the lap and to return empty-handed, four doors were opened and closed 600 times each in the 50-hr. week. On a basis of 50 weeks per year, the operator opened and closed 120,000 doors a year. Luckily, the T.S.M. had incorporated the door manipulations as a

	Old door	Revised door
With lap, open and close one door .09 min. + 15 % rest =	.104 min.	
With lap, open and close new door .03 min. + 15 % rest =		.035 min.
Return trip, open and close one door .045 + 10 % rest =	.05 min.	
Return trip, open and close new door .02 min. + 10 % rest =		.022 min.
Standard normal time =	.154 min.	.057 min.
Job has 42-ct. rate,		
$\frac{42}{60} \times .154 = \$.001078$ + overhead	\$.002695	
$\frac{42}{60} \times .057 = \$.0004$ + overhead		\$.001
Savings for opening and closing one door unit		\$.001695
60,000 × \$.001695 = \$101.70 gross saving		
Less carpenter work 4.00		
\$ 97.70 first year's net savings		

separate element. The cotton-mill overseer found two sets of swinging-door hinges in his storeroom and recommended that they be applied to the doors in place of the butt-hinge types in use. This change was made at a total of $4 for carpenter work. The T.S.M. again studied the operator as he opened the revised doors and found a shorter time, because the operator merely pushed the doors with his foot and did not have to worry about closing each door. A cost report was made as shown in the table on page 113.

This saving of approximately $100 per year does not appear to be very much in itself, but, in addition to this small amount, the man-hours saved were available for other productive work. The other operations in the mill were subjected to the same searching investigation and, although none of the individual savings were very high, the sum total of the savings was several thousand dollars per year which enabled the cotton mill to meet the prices of its competitors. The apparently insignificant item of opening and closing a door would not ordinarily receive a second thought, yet, when it was shown as a separate element on the observation sheet, it offered the possibility of real economy.

The stop watch is not in use during the whole time the operation is being analyzed and lined up for elements. The operator should always be aware of this fact. After the foreman or production engineers have answered all questions and approved of any revisions made, the operation is ready for the final step of timing. The T.S.M. is left alone with the operator at this stage, because too many persons witnessing the timing cause interruptions and confusion. When the operator is completing the elements regularly in their proper sequence and at his consistent rate of speed, he is told that the actual timing will be started.

Questions

1. Name the two general classifications of operations outlined in this chapter.
2. What are regular elements and how often do they occur in a cycle?
3. What are incidental elements and how often do they occur in a cycle?
4. Have element lengths any fixed ratio to the length of a cycle?
5. Do Internal elements influence the length of a cycle?

Problems

6. In the planer department of a machine shop, an operator is given the job of planing off the tops of 25 cast-iron motor bases. Since the planer

	Element	Ext., Min.	Int., Min.	M.T. Min.
A.	Fasten lifting chain to one casting	.23		
B.	Attach hoist and lift casting about 3 ft	.30		
C.	Move and lower casting to machine table	.20		
D.	Remove chain and push away hoist	.12		
E.	Line up casting with surface gauge	3.25		
F.	Apply and tighten four clamp bolts	1.90		
G.	Mark and center punch end pad on casting using sheet metal template	1.75		
H.	Chip off rough spots on front edge of casting to save cutting edge of tool	9.35		
I.	Insert roughing tool and tighten	.38		
J.	Position tool, start machine, and feed	.42		
K.	Take roughing cut on casting top			65.5
L.	Stop machine and feed and return tool		.36	
M.	Position tool and start machine and feed	.46		
N.	Take second roughing cut on top			65.1
O.	Stop machine and feed and return tool	.37		
P.	Remove tool, insert, and tighten finish tool	.68		
Q.	Position tool, start machine, and feed	.55		
R.	Take finish cut on top			18.8
S.	Stop machine and feed and return tool to center of table	.25		
T.	Remove tool, insert, clamp, and position pointed tool	.48		
U.	Set tool to casting center line by the center punch mark on pad at end of casting	.39		
V.	Start machine, feed tool by hand, and machine light line on the top surface of casting. This element is correct as External because operator controls the M.T.	.72		
W.	Stop machine and remove tool	.25		
X.	Grind extra planer tools	2.40		
Y.	Inspect next casting for warped condition		.57	
Z.	Consult shop order and stamp serial number on top of finished surface of casting	1.37		
1*A.*	Remove four clamps and place on bench	.65		
1*B.*	Get hoist and fasten chain to finished casting	.17		
1*C.*	Raise and move casting to finished pile	.19		
1*D.*	Lower casting to finished pile of castings	.14		
1*E.*	Brush off planer table	.62		
	Total	27.59	.93	149.4

table will hold only one casting per cycle, there is enough work for several days. The castings have all been delivered to the operator, but he must load and unload his planer table by means of a swinging electric hoist. The operator has been provided with extra planer tools and about 20 ft. from his planer there is a grinding-wheel stand where he sharpens his spare cutting tools. All handling of hoist, lifting chain, and castings to and from the machine table must be done while the planer is stopped.

The T.S.M. lines up, times, rates, and lists the average of the element normals in either the Externals or the Internals columns. He listed the normals in the columns as the operator completed the elements, but, after checking over his study, he found that four of the elements he had specified as Externals should have been Internals. Also, he listed as an Internal one element that should have been an External. His line-up of elements before he discovered his error was as shown in the table on page 115.

The reader should study each of the elements, *A* to 1*E* inclusive, and then specify the four improperly posted Externals. Also, he should specify which of the two Internals should have been an External.

7. In Prob. 6, what was the length of the cycle before the time-study error was discovered?

8. In Prob. 6, what is the correct cycle length?

9. In Prob. 6, what is the percentage of time saved by correcting the cycle length?

10. If the planer operator in Prob. 6 had an hourly rate of 72 cts., what is the labor cost of element *E* (line up casting with surface gauge) after adding a 14 per cent rest factor to the 3.25 min. N. as specified?

Answers to Questions

1. Manual and machine operations.

2. Regular elements are ones that occur at least once in each cycle.

3. Incidental elements are ones that occur every few cycles.

4. No. Elements are established for the purpose of cycle analysis and time measurement. To accomplish this, the scope of elements is determined by the natural subdivisions of the cycle or is specified for suitable briefness regardless of cycle lengths.

5. No. Internal work elements are performed while the machine is producing without the aid of the operator. If he is too leisurely in his performance, the Internal work may not be completed before the expiration of the M.T. If so, the Internals automatically become Externals for that period of time when the machine actually waits on the operator.

Answers to Problems

6. The four improperly posted Externals are

> *Element G.*—The normal should be 1.75 min. Internal because the operator can use the template on the next rough casting in the pile to be worked on.
>
> *Element H.*—The normal should be 9.35 min. Internal because the operator has ample time to chip the next casting as it lies in the pile awaiting its turn to be worked on in the machine.

Element X.—The normal should be 2.4 min. Internal. The operator had been supplied with spare tools and, as the grinding stand is only 20 ft. away, he can easily watch his job and grind his spare tools during M.T.

Element Z.—The normal should be 1.37 min. Internal. The stamping of the serial number can be done on finished castings after they are removed from the machine table.

Element L.—Its normal of .36 min. should have been posted in the External column because the machine is stopped while the tool is being returned to its first position.

7. Original total Externals 27.59 min.
Add the M.T. 149.40 min.
Cycle length = 176.99 min.

8. Original total Externals 27.59 min.
Remove element *G*, normal 1.75
Remove element *H*, normal 9.35
Remove element *X*, normal 2.40
Remove element *Z*, normal 1.37 14.87
12.72
Add on the misposted External .36
Corrected total Externals 13.08 min.
Add the M.T. 149.40
Correct cycle[1] = 162.48 min.

9. $\frac{176.99 - 162.48}{176.99} = 8.2$ per cent saving in cycle length

10. $\frac{72}{60} \times 3.25 + 14$ per cent $= \$.012 \times 3.71 = \$.0445$, cost of lining up one casting as specified by element *E*.

[1] Chap. IX takes up the use of the Reduction Factor for machine operations. The reader is cautioned against applying the cycle principles of Chap. VI to his work until he has mastered Chap. IX.

Chapter VII

Chapter VII starts the actual use of the stop watch and the normalization of time measurements. You can easily spend one whole hour or longer on Fig. 6. Read thoroughly the pages which explain the items on the Shop Observation Sheet for John Doe's packing operation on peach cans. Use your slide rule to check the figurations for elements *A* to *I*, inclusive. The normal .076 min. for element *A* was determined from high, average, and low positions. You will have many similar operational elements in your professional application of time study, so it is well to appreciate the wisdom of timing elements in a complete manner.

In this chapter is shown an illustration of a Shop Observation Sheet whose design is recommended for your use in collecting data in the plant. Its style will suffice for any type of job studied, and is especially suitable for jobs where data must be posted rapidly.

CHAPTER VII

THE SHOP OBSERVATION SHEET AND THE TIMING OF MANUAL OPERATIONS

At this stage of time study, the T.S.M. has informed himself about the operator, material, conditions, machines, methods, and all other pertinent data connected with the operation under diagnosis. He has set up elements for the subdivisions of the task and also for the appropriate movements of the worker. The elements established specify the official method by which the operation is best completed. Therefore, the T.S.M. is ready for the time measurements of the elements.

In order to record the measurements of the various elements, a suitable form of observation sheet should be designed. Each plant has its own particular kind of product and the time-study problems surrounding the product might call for the use of a style or form of observation sheet not applicable to another plant. The detailed form should be designed to fit, as nearly as possible, ramifications of all the problems encountered in each organization.

We do not favor the form of observation sheet where the space devoted to watch readings is made up of small windows or individual sections in which the timings and ratings are posted. Unless the T.S.M. takes time to be extremely neat with figures, he may have trouble in confining them to small, fixed spaces, especially at a time when his attention should be almost entirely centered on the job before him. His attention should be as undivided as possible. He should have sufficient space to write as large as he ordinarily does so that there may be no handicap imposed by the need of wedging figures into small spaces. The continuous method of timing almost necessitates the use of small window spacings, but since we believe the snap-back method is more modern, the form of observation sheet can be of simpler construction and can allow more latitude for the T.S.M.

The space used for specifying the description of each element in the operational lineup should be elastic enough to accom-

modate properly all such descriptive legends whether they are of considerable length or are quite brief. Forms are not primarily created for the purpose of saving paper but are used for efficiency. Consequently, the style of form used should not only provide ample space for legends, watch readings, and ratings but also should permit much other data, including references, notes, and other items, all of which must be rapidly entered on the sheet.

Figure 5 covers a style of shop observation sheet which can be applied to almost any industry. It is 8½ by 11 in. in dimensions, which is the regular business-letter size and may be filed in the conventional office filing cabinets. The paper should be of a cheap grade of white paper that will stand erasures. The captions, figures, etc., should be printed in black. The horizontal and vertical lines can be printed in either blue or black. A few dimensions are given, since the illustration is not full size. Otherwise the sheet is self-explanatory.

The Shop Observation Sheet is a work sheet of a T.S.M. and made out by him in the factory departments after he lines up each operation preparatory to timing. In the next chapter, the Master Observation Sheet is outlined. This latter sheet either condenses or expands the data recorded on the Shop Observation Sheet.

On many of the observation sheets in use throughout the nation, there is a space devoted to the making of sketches of the work and its transformation during some given operation. Upon examination of various observation sheets, it was found that, if the piece of work required any talent of draftsmanship to portray, the sketch space was usually left blank. Those spaces having sketches generally contained freehand sketches of flat strips of metal or simple lathe parts, the outlines and dimensions of which were taken from the blueprint in use on the job. Since the blueprint is the only proper reference to follow, sketches should not be made unless there is some advantage in so doing. Whenever sketches are desirable, they can be made on the back side of the sheet.

Besides containing the items of watch readings and ratings, the Shop Observation Sheet is used to record many notes, machine data, tools used, amounts of material removed, setups, preparation work, tool sharpening, delays, or any other information that

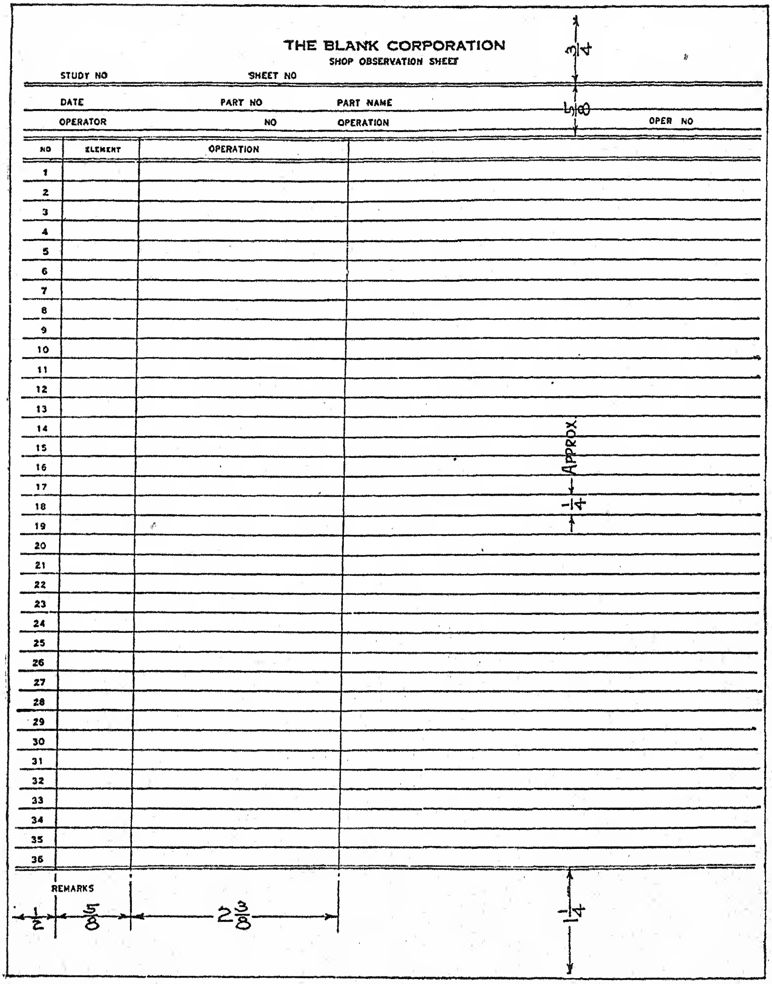

Fig. 5.—The Shop Observation Sheet.

will be helpful in building standards. Months after a study is taken, a time study is sometimes withdrawn from the files to settle some question that has arisen. It is most reassuring when the T.S.M. recognizes in the almost forgotten study some note or comment that refreshes his memory on an obscure detail and thereby proves his point.

Until the reader has gained considerable time-study experience, he should carry with him a pocket-size notebook containing questions which he should ask himself or others regarding operator, material, machine, etc., as outlined in the previous chapters. In this notebook will be many reminders of points he might overlook, thereby leaving an unfinished time-study job. Other data will be given as the reader progresses and these also should be added to his notebook.

To measure the elements, the T.S.M. takes a position near the operator as described on page 111. He knows when to anticipate the end of each element because he previously determined its scope.

At the instant element *A* commences, he starts his watch and concentrates on the effective speed being demonstrated during the element. As the end of element *A* approaches, the pencil is poised over the observation sheet and the moving watch hand observed. At the precise ending of element *A*, the T.S.M. notes the exact time and, while doing so, snaps the watch hand back to zero. As the watch hand is again starting forward for the next element, he records the time and rating for element *A*. After this is quickly done, he concentrates on element *B*. In the same manner, he awaits completion of *B* and then posts his time and rating while the watch is beginning to register the next element. This same process is repeated for each subsequent element in the cycle. At the end of the cycle, he has not obtained an over-all watch reading but has collected individual times for each element. Having timed one cycle, the T.S.M. times and rates several cycles.

The amount of cycles to be studied depends upon the T.S.M. and also upon the job. As a general practice, about 10 cycles should be studied, provided the timings show an even performance and the ratings for each element are thought to be correct. There is a tendency to take many timings on short operations

and few observations on long ones. No matter how skilled a T.S.M. may be, he should take at least three timings on very long cycles, even though it requires several days of his time to do so. A minimum of three cycles, obtained from a very good operator performing on an even type of work, offers opportunity for comparison of at least three timings. Long cycles are costly operations and theoretically should receive a lot more attention and time postings than short operations because the savings are usually greater in percentage. The rule for a T.S.M. to follow concerning the proper number of observations to be taken is for him to stay on the job long enough to be sure of his time measurements.

If it requires the timing of 50 cycles to confirm his judgment, the T.S.M. should not hesitate to take that many timings before he leaves the job. If the operator, as stated, is working at a brisk, even pace on work that is not of a variable nature, about 10 cycles should be recorded. Often, many elements can be measured after five or six observations, but longer time may be spent on the operation to be sure of other elements in the cycle.

A Shop Observation Sheet which is literally filled with dozens of observations does not always signalize an accurate study. An operator may have been timed so long that the fatigue of the worker injected a new factor which caused marked differences between the first and last cycles studied and which introduced another item of adjustment in the ratings assigned.

After timing a few elements in a cycle, the T.S.M. may time, rate, and post a reading for some given element and be so sure of the time measurement that he deems it unnecessary to time that particular element any more. It is a timing that "clicks" and he is convinced at once that it is the appropriate one to use; therefore he draws a circle around the posting and continues timing the other elements until he is satisfied with the data obtained for them. It is not necessary to show a circled posting for each element in a cycle and the T.S.M. should not establish a posting in this fashion unless he honestly "sees" it. Circled postings, if not directly used, can be used as an index for other fluctuating watch readings in elements that receive varying ratings.

There are at least two main reasons why variations in watch readings will occur in a manual operation on some particular element. These reasons may occur singly or in combination. They are

1. Variable material requiring varying effort.
2. Erratic performance on the part of operator.

In the first case, although an operator may be highly skilled and working at an even rate of speed, nevertheless varying watch readings will be posted. If the tool equipment and the surrounding conditions are satisfactory, the differences in postings will be due to the nature of the material, over which the operator has no control. Where varying material causes time differentials, it must be classified into Good, Average, and Bad divisions and studied accordingly. This will be explained in detail when the item "variables" is reached in Chap. X.

The second case not only requires the application of different ratings for fluctuating watch readings in each element but also implies that the range of ratings for each element as a whole may vary considerably. To illustrate this condition:

An assembly operation is being studied. Although the watch should reflect fairly even timings, the operator is erratic in his demonstration. Omitting the watch readings, the ratings for each element are

Element *A*	75R.,	70R.,	75R.,	70R.,	65R.
Element *B*	40R.,	45R.,	60R.,	40R.,	45R.
Element *C*	80R.,	85R.,	70R.,	75+R.,	80R.
Element *D*	60R.,	55R.,	55R.,	65R.,	50R.
Element *E*	50R.,	50R.,	40R.,	55R.,	70R.

In the foregoing example, it is noted that, aside from the necessity of different ratings for each element, the range of ratings is not the same for each element. Thus, in element *B*, the operator was not only erratic but very slow, whereas in element *C* this same operator was much faster, although not even in his endeavors.

It was stated in Chap. IV, that the application of a rating transposes a watch reading to a normal. On the basis of this principle, no matter how fast or slow an operator is, a proper rating will provide a proper normal for the completion of an element. With regard to element *A* in the foregoing example, the ratings range from 65R. to 75R. Still assuming the element is not of a variable nature and that the ratings were

specified for the operator's irregular effort, the normals obtained from each of the five ratings in element *A* should be almost alike. If they are not, it is because the ratings were wrong. Attaching the watch readings for element *A* on the preceding page, the T.S.M. timed and rated each of the five cycles as follows:

Element *A*, first	reading 2.40 @ 75R.	= 3.00 min. N.
Element *A*, second	reading 2.50 @ 70R.	= 2.92 min. N.
Element *A*, third	reading 2.35 @ 75R.	= 2.94 min. N.
Element *A*, fourth	reading 2.52 @ 70R.	= 2.94 min. N.
Element *A*, fifth	reading 2.74 @ 65R.	= 2.97 min. N.

An examination of the extreme normals shows 2.92 min. N. as the smallest and 3.00 min. N. as the greatest. These extremes are 2.92/3.00, or within 97+ per cent of each other, which indicates the T.S.M.'s skilled rating ability.

If the fluctuations of watch readings are pronounced, an analysis should be made to trace the differences to some definite cause, whether it is the job or the man. Averages of watch readings should never be taken unless the fluctuations are within a small range of variance. Neither should one follow the practice of selecting the shortest or the longest times in an element. The normals specified are the ones the T.S.M. feels are equitable for the final standard. Often the frequency of the same watch readings per element is the best means of selecting the postings to be normalized. For example, in 10 cycles, six of the watch readings for some given element received ratings of 70; two, 65; and the other two, 80. It would seem desirable to normalize the six readings of 70R. each, provided, of course, the six items of time were very nearly alike. A check on judgment in this case would be to normalize the two readings with the 65R. and also the two with the 80R. The percentage of difference between these extremities would either indicate a rating error for one of the extremities or confirm the position of the six watch readings that were selected.

Although no dogmatic statement can be made about the allowable percentage of differences between watch readings per element, nevertheless, a safe rule to follow is this: On an element in an even type of operation, the variation of an operator's effective speed should not cause the normals obtained from the fluctuating watch readings to vary more than 85 per cent between the lowest and the highest. Even this 15 per cent latitude cannot be

permitted if the element in question occupies a major part of the cycle. This rule may be clarified by the following example:

A short-cycle operation of dipping metal parts, one at a time, into a tank of paint carried these elements, timings, and ratings:

A.	Pick up one part, wipe off, and insert wire hook in end hole	.03, .03, .03, .04, .03 @ 80R.
B.	Dip part into the paint tank	.40 @ 80R., .44 @ 65R., .45 @ 60R., .45 @ 60R., .50 @ 50R.
C.	Remove and hang by hook on drip rack	.06, .07, .06, .07, .06 @ 65R.

The fluctuations of watch readings in elements *A* and *C* are so small that the ratings in each were applied to the averages. However, the operator was so erratic for element *B* that the T.S.M. was forced to specify widely different ratings and he found himself in error on one of them. He caught his error by reducing all the element *B* readings to normals and then carefully examining them. The normals for *B* were correctly computed as .533 min., .477 min., .45 min., .45 min., and .417 min. N. The percentage of the extremes was .417/.533 = 78.3 per cent, which the T.S.M. decided was too much variation. Using the two .45 min. normals as a trial base, he found they were 7.91 per cent larger than his smallest normal specified and that his largest normal was 18.5 per cent larger than the .45 min. base. Thus he decided the .533 min. was in error and accordingly removed it from consideration. Notwithstanding the fact that he tried an average of the four remaining readings, which is .449, he decided to call .45 min. the Allowed Normal. This somewhat elaborate consideration was believed advisable because the element was a major part of the cycle.

Where neither job nor operator is consistent, the T.S.M. should request the services of a more even type of man. On jobs where several operators are all working on the same operations, the T.S.M. has a much better chance to arrive at the normals because several watch readings taken from several operators offer more comprehensive data for comparison.

The period of the day sometimes influences the evenness of an operator's effort. If he is studied late in the afternoon, he may be too tired to work in an even, systematic manner. Perhaps if the T.S.M. has had a trying day, he, too, is tired and cannot

"see" ratings as he should. Many time-study men endeavor to study the harder types of operations during the morning hours and save the easier ones for the afternoons.

Sometimes the unevenness of watch readings is occasioned by the fact that an element is too long. The proper length of elements has been dealt with in an earlier chapter, but it is well to state again that short elements are apt to yield more even watch readings than long ones. Unevenness of performance often accrues from the operator who, because he is being observed, works faster than his regular pace. If this is true, he should be slowed down to a pace that is more uniform.

In plants where there are several kinds or sizes of the same product, the T.S.M. can defer certain ratings, of which he is not sure, until he has studied several or all of the different product sizes. After he has studied various operators on the correlative sizes, his normals can be refined to equality with the graduated sizes of product. Where the products in another plant are of a miscellaneous type and therefore not subject to a size-factor basis, the T.S.M. can always find some similar item of work that offers a means of comparison. This may be sawing, filing, chipping, nailing, digging, etc., that can be either compared directly to the new study or interpolated to serve as an item of similarity.

On extremely short cycles of .03 min. or less, the T.S.M. can time 10 pieces at once. The timing should be done, however, on an operator who is performing uniformly. Also, the watch readings should receive most careful selection. For illustration, if one reading shows .02 min. for an element and .04 min. for another reading of the same element, the difference is only .02 min., yet that is a difference of 100 per cent. Many standards covering short cycles are loose simply because the variations in watch readings were not also considered from a percentage standpoint.

A T.S.M. should not be fooled by the burst of speed that an operator may display at the beginning of each cycle. The first few elements in each may be done at a very fast rate of speed, for which high ratings are granted. The rest of the elements in each of the cycles may be completed at a much slower speed and the T.S.M. will, unless he is alert, allow higher ratings than advisable for the slower elements, because the first few unconsciously prejudiced him in favor of the higher speed that was displayed.

THE BLANK CORPORATION
SHOP OBSERVATION SHEET

STUDY NO. 1252 SHEET NO. 1

DATE JAN. 12, 19– PART NO. 3P45 PART NAME ONE QUART CAN SUNSHINE PEACHES

OPERATOR JOHN DOE NO 15-97 OPERATION PACK № 2 BOX OPER. NO. 16

NO.	ELEMENT	OPERATION	POSITION OF BOXES ON TRUCK		
1	A	Place empty box and 3	HIGH	AVERAGE	LOW
2		boards on bench.	.07-.08-.09	.06-.04-.06	.04-.03-.05
3			.07-.10-.08	.04-.05-.05	.05-.04-.03
4		(Good 80R for all-take	.10-.10-.07	.05-.06-.04	.03-.05-.05
5		average)	.08-.07-.07	.04-.04-.06	.04-.04-.03
6			AVER. NORMAL = .076N.		
7	B	Using both hands, pick	.06 .06 .06 .07 .06 .07 .06 .07 .06		
8		up 3 cans from conveyor	.07 all @ 80 R. See line 13.		
9		and stack in box.			
10					
11	C	Repeat element B 11 times	Timed 36 cans or full box or 12 passes = .78 @ 80R		
12		(Timings are on Harry	" 33 " " 11 " = .70 @ 80R		
13		Doe)	Call .085 + 6% = .09/3 = .03 N per can.		
14	D	Place packing slip on top	~~.06~~ ~~.07~~ Timing on Edw. Doe .03 @ .85 .04 @ 65		
15		layer of cans.	.043 N		
16					
17	E	Place 3 boards on box top	~~.10~~ ~~.09~~ Timing on Edw. Doe .04-.05-.04-.05-.05		
18			.06-.04-.03-.05-.04 @ 80 + R Take average .062 N		
19					
20	F	Line up board and drive	16 @ 75-R .15-.14-.15-.15-.15-.16-.16		
21		3 nails in each end.	Call .15 @ 80 = .20 N		
22					
23	G	Repeat F for other end	Same as element F see line 21 above		
24		board.			
25					
26	H	Drive 3 nails in each	.15-.14-.15-.15-.15-.14-.14-.14 Average		
27		end of center board.	1.16/8 @ 80 R = .193 av. N		
28					
29	I	Push finished box into	.03-.04-~~.06~~-.04-.03-.04-.03-.04-.04		
30		chute.	.04-.03 Average @ 75 R = .045 av. N		
31					
32					
33	B	In picking up 3 cans	the operater slides 3 together in form of 3		
34	and	leaf clover before pic	king up.. He places group in this fashion in		
35	C	box and then stacks	into 3 crosswise and 4 lengthwise rows		
36		each 3 tiers high.			

REMARKS Box holds 36 cans. Use total of 18 nails. No set-ups or preparation work. All materials and supplies furnished by Indirects.

FIG. 6.—The Shop Observation Sheet containing data covering a simple type of manual operation.

To amplify some of the statements made in this chapter, we shall assume that a T.S.M. is ready for the actual timing of an operation in a fruit-canning factory. The operation is known as operation 16, to pack a No. 2 box with 36 peach cans and nail on the box top. A moving conveyor is constantly supplying the finished cans of fruit to three operators assigned to operation 16. The volume of production requires the services of three men, hence each is doing the same kind of work.

The T.S.M. has previously made his contact and suggested a few changes in the line-up of movements which were approved by the superintendent. The supply of empty boxes is located on trucks within 3 ft. of the left side of each operator. The box tops, consisting of three boards each, are also located on the same trucks. Within 3 ft. of the right side of each operator is the moving conveyor containing the cans to be packed. After each operator has packed and nailed up his box, he pushes the finished box off the back side of his bench into a chute which conveys the box to the shipping room downstairs. The correct line-up of the job is as follows:

A. Place empty box and three boards on bench.
B. Using both hands, pick up three cans from conveyor and stack in box.
C. Repeat element *B* 11 times.
D. Place packing slip on top layer of cans.
E. Place three boards on box top.
F. Line up board and drive in three nails in each end.
G. Repeat element *F* for other end board.
H. Drive three nails in each end of center board.
I. Push finished box into chute.

Figure 6 shows timing, ratings, notes, etc., on the Shop Observation Sheet as the T.S.M. analyzed and measured the operation. While he was timing the job, a student T.S.M. was watching. Afterward he asked a number of questions as the actual watch readings were being normalized. The regular T.S.M. explained every step of his figuration for the different elements.

For element *A*, he explained that John Doe gave him a very good demonstration and that the effective speed was worthy of an 80R. He stated that, when the operator was required to pull off his next empty box from the top of a fresh truckload, it took a longer time to procure it. So he timed the operator getting the boxes from high, average, and low positions on the truck.

He took 12 timings of each of the three positions and arrived at normals for each position. The figuration was as follows:

High	= $.^{98}/_{12}$ @ 80R.	= .109 min. N.	for high in pile
Average	= $.^{59}/_{12}$ @ 80R.	= .066 min. N.	for average height
Low	= $.^{48}/_{12}$ @ 80R.	= .053 min. N.	for low in pile
		.228 min./3 = .076 min. average normal allowed	

Thus, in the allowance of .076 min., the operator was given a normal for the average work required to unload one box and its boards from the supply. This answered the student's question of why element *A* had fluctuating watch readings.

Since the demonstration given for the element *B* was also a very good one, an average of the 10 actuals was normalized and .085 min. was obtained as the average normal. It was noticed that it took slightly longer to place the first layer of cans in the box but that this was offset by the shorter times for the top row which was the easiest to pack. The T.S.M. observed that Harry Doe was performing with an ideal rhythm of motion; therefore, he was timed for element *C* covering the packing of a full box of 36 cans and his effort was so even that the watch was left running. His actual of .78 min. when normalized yielded .087 min. for three cans. He was also timed on 11 passes and his normal per pass showed .085 min. The T.S.M. explained that he would use .085 min. but would add on 6 per cent allowance because the operators might receive complaints from the inspectors if the cans were assembled in the boxes any faster than the speed shown during the time study. Therefore, .085 plus 6 per cent = .09 min. Allowed Normal for three cans or .03 min. N. per can.

When the student inquired why the first two timings in element *D* were crossed out, the T.S.M. replied, "John Doe gave me very good cooperation up to this point, but, for some reason or other, he decided to give me a 'sleigh ride' on element *D*. Rather than speak to him about it or apply a rating for the two crossed-out timings, I decided to measure Edward Doe. The latter's first actual just 'clicked' and I knew I could have stayed there all day without being any more sure of a rating than I am over the one I circled. Therefore, my normal of .043 min. which I obtained

from my circled posting will be specified for element *D* even though I have only one other regular reading."

For the same reason as for element *D*, the first two readings in element *E* were struck out. John Doe spent too much time in positioning the three boards on the box and knew that the jar caused by one hammer blow would dislodge the accurate location of them. Edward Doe was studied and his 10 readings of 82.5R. prescribed .062 min. as the normal to position roughly three boards preparatory to nailing them down.

Elements *F* and *G* were studied together and the eight readings were normalized as follows:

First reading	= .16 @ 75R.	= .20 min. N.
Other seven readings	= .15 @ 80R.	= .20 min. N.

Element *H* required positioning only in a lateral way and so the normal of .193 min. was slightly less than for the other two nailing elements.

The student inquired why the third reading in element *I* was struck out. He remembered that the operator, in the midst of the timing, had stopped and wiped off his forehead and that the watch had accumulated .06 min. before it was stopped. The T.S.M. pointed out that delays of this kind were not recognized while the timings were in process. Ample time for the operator to wipe off his forehead would be allowed when the fatigue factor was later applied. An average of the other 10 readings was normalized and .045 min. N. was granted.

The T.S.M. stated that he had made a few notes at the bottom of his study so that if any question arose a year later, his notes might help to clear up the point in dispute. He also stated that operation 16 was considered a fairly short cycle; it was an even type of job and consequently should not reflect widely varying performance. Elements *F*, *G*, and *H* required the most skill, but a skill which was quickly acquired, and elements *B* and *C* required a knack of handling the three cans without dropping them or imposing an undue amount of arm strain.

"Whenever you time a job," said the T.S.M. to the student, "be sure that all work you have time-studied is set aside and officially inspected and passed for quality and accuracy. Never leave the operation until this inspection operation is done,

because if you overlook this the operators might later on try to put through some improper work and then contend that it was no worse than the quality made during the period when the job was being observed and timed."

Questions

1. What are the two main reasons why manual operations may show variations in watch readings?

2. Does the length of an element ever influence variations in watch readings?

3. What is one reason why standards covering short cycles are sometimes too loose?

4. Why should the work upon which time studies were taken be set aside and disposition made of it before the T.S.M. starts studies on another job?

5. Upon what basis can averages of watch readings be taken for each element to be normalized?

Problems

6. Normalize the five watch readings below by using the ratings attached to each. One rating is obviously wrong—which one is it? Using the four remaining normals, what is their average?

1.20 @ 80R. 1.58 @ 60R. 1.47 @ 65R. 1.93 @ 50R. 2.50 @ 30R.

NOTE: Specify normals to only two places to the right of the decimal point.

7. On page 128, what is the sum of the normals for elements *A*, *B*, and *C* in the paint-dipping operation? Carry normals to four places to the right of the decimal point.

8. With reference to elements *A* to *I*, inclusive, on page 131, what is the total normal time allowed to pack one box of 36 cans, as in operation 16?

9. On a certain operation in a fishing-rod factory, the material is uniform and should therefore reflect fairly constant watch readings. However, the operator was erratic in his performance and the T.S.M. was forced to use several different ratings for one of the elements. The watch readings and ratings were as follows:

4.45 @ 70R. 6.5 @ 55R. 4.8 @ 65R. 3.6 @ 80R. 7.8 @ 40R.

Normalize all five postings and state whether there was a rating error in any of them as evidenced from a study of each normal. Before you strike out any posting, determine what ratio in percentage the smallest normal bears to the largest normal. Which one or more normals would you strike out in this even type of operation? What normal would you allow for the element in the operation?

10. If a watch reading is 4.2 min., what rating would you prescribe to convert the reading to 3.15 min. N.? Also show the slide-rule setting for it. Use the regular graphic form as presented many times in Chap. III.

Answers to Questions

1. The two main reasons may be, singly or in combination:

1. Variable material requiring varying effort.
2. Erratic performance on the part of operator.

2. Elements have been previously established before timing and the scope of each element represents a correct subdivision of the work involved. Yet, if the element is of such nature that the operator cannot perform with a rhythm of motion, fluctuations in watch readings are apt to occur. Again, the items of work making up an element may be so dissimilar as to prevent even watch readings.

3. Because the variations in watch readings were not also considered from a percentage standpoint.

4. All work produced during the actual timing of the operation should receive an official approval as to quality and accuracy before the T.S.M. builds the standard for it. This approval is obtained from the inspectors, foremen, or others who are responsible for the work in process. If the work produced under time-study observation is satisfactory, the T.S.M. expects a maintenance of the same satisfactory quality and accuracy after the standards are put into effect.

5. Averages of watch readings should never be used as a basis for arriving at average normals, unless the watch readings per element are confined to a limited range of variation. If variations are appreciable, the use of proper ratings will reconcile the actual timings to proper normals.

Answers to Problems

6. 1.20 min. @ 80R. = 1.60 min. N.
1.58 min. @ 60R. = 1.58 min. N.
1.47 min. @ 65R. = 1.59 min. N.
1.93 min. @ 50R. = 1.61 min. N.
2.50 min. @ 30R. = 1.25 min. N. Should be about 38R.
6.38/4 = 1.595. Call 1.60 min. Av. N.

7. (*A*) $\dfrac{.03 + .03 + .03 + .04 + .03}{5}$ @ 80R. = .032 @ 80R. = .0427 min.

(*B*) It was stated that the T.S.M. selected normal = .4500 min.

(*C*) $\dfrac{.06 + .07 + .06 + .07 + .06}{5}$ @ 65R = .064 @ 65N. = .0694 min.

Total normals = .5621 min.

8.

Element		Normals
A		.076 min.
B	3 cans × .03 =	.090 min.
C	33 cans × .03 =	.990 min.
D		.043 min.
E		.062 min.
F		.200 min.
G		.200 min.
H		.193 min.
I		.045 min.

Total for one box of 36 cans = 1.899 min. Call 1.9 min. N.

9. 4.45 min. @ 70R. = 5.19 min.
6.50 min. @ 55R. = 5.96 min. rating too high
4.80 min. @ 65R. = 5.20 min.
3.60 min. @ 80R. = 4.80 min. rating too low
7.80 min. @ 40R. = 5.20 min.
15.59/3 min. = 5.197 min. Call 5.20 min N. allowed.
4.80/5.96 = 80.5 per cent agreement. Should be 85 per cent or more.

10. The correct rating is 45R.

C	Set 4.20 min.	Under 60R.	= answer
D	on 3.15 min.	Read 45R.	

Chapter VIII

In its treatment of building standards on manual operations, Chap. VIII takes up the energy values called Credors. A definition of Credors is given and its name is constantly used throughout the remaining chapters.

You will note in this chapter that John Doe's packing operation has been "boiled down" into a standard as shown in Fig. 8. The toy-assembly operation as shown in Fig. 9 will give you additional slide-rule practice and we recommend that your close attention be given to the paragraphs that describe the time measurements for this toy job as covered by Figs. 9 and 10.

When solving Prob. 4, try to place yourself in the position of actually doing this time-study operation—even to the point of having some member of your family go through the motions of handling a drawer from your desk or table. You should time them and then reverse the process by having them time you. It is not expected that you will have the jig or the electric drill that is called for in elements *B* and *C*, but you can go through the motions just as if they were actually being used.

With reference to Fig. 12, no explanation is offered in this chapter concerning the rest allowances specified for use in Prob. 5; they are to be used when the standard is being built, so that time-study procedure may be unfolded to you in a logical step-by-step manner. To inject factors of fatigue at this point would cause confusion. As rest factors are explained in Chap. XIII, consideration of rest allowances will be postponed until that chapter.

CHAPTER VIII

BUILDING STANDARDS ON MANUAL OPERATIONS

The Master Observation Sheet, as outlined in this chapter, is a summary sheet of all data necessary for the building of a standard. It may receive data from various sources, but mainly from the Shop Observation Sheets.

Figure 7 covers the style of form we believe is applicable to general use. Since the illustration is not full size, a few dimensions are given. It is 8½ by 11 in. in size and therefore can be filed in regular office filing cabinets. The paper should be white and of a better grade than used for the Shop Observation Sheets. The printed matter should be in black ink, though the various lines may be blue or black.

Each time study should be given an individual study number. The numbers for each study should run consecutively from 1. The same number is given to all sheets that make up the group of data for one complete time study.. On the Master Observation Sheet, this number appears in the upper right-hand corner in the space assigned.

The Date Written space contains the date on which the master sheet was completed, which may be much later than the dates appearing on the Shop Observation Sheets.

The Material space receives the official specifications for the material. This is secured from blueprints or shop records. The information should be as complete as possible. For example, "2⅝-in. diameter by 12¼ in. long 2045 steel, P heat-treatment, 38 m/m Brinell hardness" leaves no doubt in the minds of machine-shop executives as to the nature of the work upon which studies were based.

In the space prescribed, the operator's clock number and name are entered and the sex indicated by crossing out the opposite sex title. Sometimes the data for a study are secured from several different operators, in which case the space will contain a reference to the several names, thus, "See Sheet 5, line 23," etc.

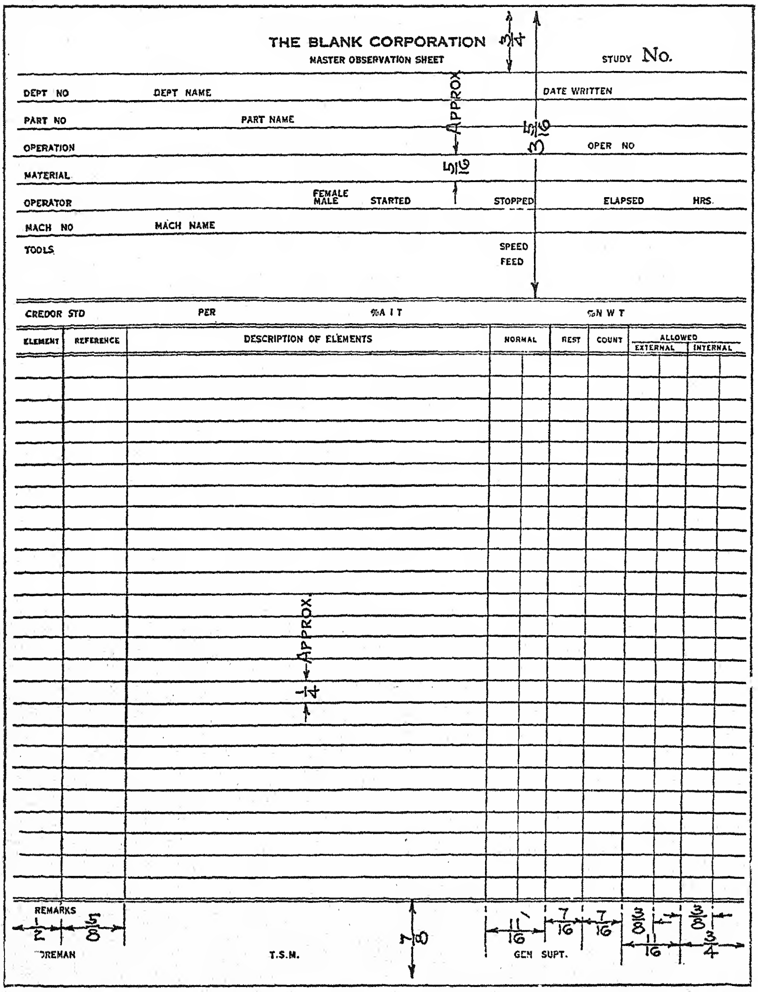

FIG. 7.—The Master Observation Sheet, which receives data from the Shop Observation Sheet.

The Started and Stopped spaces show the date and hour the analysis and timing of the job started and the date and hour they were completed. The hour of the day may have some effect on the performance of an operator and the ratings allowed. In the Elapsed space are the approximate hours spent on the job. This last posting is used to disarm the possible criticism that the T.S.M. did not spend enough time on the job to collect his data intelligently.

The Tool space contains names and numbers of jigs, fixtures, gauges, and tools that were used for the operation regardless of whether they are standard or special. Where the list of tools is too lengthy for the space, reference can be made to the sheet upon which the complement of tool equipment will be located.

All other captions above the first double-ruled line should be self-evident.

The Reference Column specifies study, sheet, and line number of the source of the data that are listed in the vertical columns. In studies of considerable length, this reference enables one to refer quickly to the exact spot where the data will be found. This reference column sometimes directs attention to some other study or to standardized elements contained in tables or curves that are filed in book form.

The Normal Column receives the normals of the different elements which have been normalized on the Shop Observation Sheets. The Allowed Normal is merely transferred to the master sheet.

The Rest Column contains the percentage of fatigue or rest allowed to the operator to maintain the time specified for the element. Therefore, the normal is increased by the percentage of rest allowed and the product is posted in either the External or the Internal columns. Since both the Rest and the Count columns will be treated fully in later chapters, they will be dismissed at this time.

The total time allowance granted for the completion of an operation is called a standard. We may prefix a name to this and call it a Credor Standard. This compounded word is made up of portions of two other words, credit and labor. Thus, a Credor is a credit for the labor necessary to complete a given task. We may then have this definition:

Credor.—A minute's worth of work, containing part labor and part rest, each of which may vary in proportion, but the sum of which always equals unity.

A corollary to this rule is: A Credor represents the energy expended or the work done during 1 min. by an average operator working at an average rate of maintainable effective speed and producing work under average conditions.

Since a Credor is part work and part rest, it may be further explained as follows:

$$\begin{array}{rl} .000 & = \text{minutes normal allowed} \\ \underline{.000} & = \text{percentage of rest added} \\ \text{Sum } .000 & = \text{one} = \text{unity} = \text{Credor Standard} \end{array}$$

Thus, a Credor Standard, abbreviated to C. Std., is the standard time allowance for the completion of an operation, taken from the grand total of the time postings in the External and Internal columns on the Master Observation Sheet.

On manual operations (all work is External), the production per hour obtained from a normal operator, is found by dividing 60 min. by the C. Std. In a previous chapter, it was stated that a satisfactory wage-payment incentive plan will cause operators to produce 80 min. of work per hour instead of the regular 60 min. per hour. Therefore, to find the anticipated production per hour, an 80-min. hour is divided by the C. Std.

$\frac{60 \text{ min.}}{\text{C. Std.}}$ = production per hour from operators without incentive plan.

$\frac{80 \text{ min.}}{\text{C. Std.}}$ = production per hour from operators with incentive plan.

The above production per hour formula applies only to manual operations. For hourly productions on machine operations, a different formula will be given in the next chapter. Also, the % N.W.T. space, called the Per Cent Normal Working Time, will be outlined. In the case of manual operations, the normal working time is 100 per cent, because the operator is not idle while waiting for a machine to complete its part of the cycle.

Figure 8 shows the Master Observation Sheet made out for the fruit-canning operation in Chap. VII. The rest factors attached to each element are used without further comment at this time.

THE BLANK CORPORATION
MASTER OBSERVATION SHEET

STUDY No. 1252

DEPT NO 15 DEPT NAME PACKING DATE WRITTEN JAN. 13, 19—

PART NO 3P45 PART NAME ONE QUART CAN SUNSHINE PEACHES

OPERATION PACK №2 OX OPER NO 16

MATERIAL SEE DRAWING 3P45-130

OPERATOR 15-97 JOHN DOE ~~FEMALE~~ MALE STARTED 1-13-9^{00} AM STOPPED 1-13-10^{30} AM ELAPSED 1½ HRS

MACH NO BENCH MACH NAME

TOOLS
SEE ABOVE DRAWING

SPEED CONVEYOR = 30 F/M.
FEED

CREDOR STD 2.16' PER BOX OF 36 CANS % A I T % N W T 100%

ELEMENT	REFERENCE	DESCRIPTION OF ELEMENTS	NORMAL	REST	COUNT	ALLOWED EXTERNAL	ALLOWED INTERNAL
A	1252-1-6	Place empty box and 3 boards on bench	.075	12%	1	.084	
B	" 1-13	Using both hands, pick up 3 cans & stack in box	.030	15	3	.104	
C	" 1-13	Repeat B eleven times	.030	15	33	1.139	
D	" 1-15	Place packing slip on top layer of cans	.043	8	1	.046	
E	" 1-18	Place 3 boards on box top	.062	10	1	.068	
F	" 1-21	Line-up board and drive 3 nails in each end	.200	12	1	.224	
G	" 1-21	Repeat element F for other end board	.200	12	1	.224	
H	" 1-27	Drive 3 nails in each end of center board	.193	12	1	.216	
I	" 1-30	Push finished box into chute	.045	16	1	.052	
						2.157	
				Use	2.16	C. Std.	
		$\frac{60}{2.16}$ = 27.8 boxes per hour @ 60 Credor Hr.					
		$\frac{80}{2.16}$ = 37.0 " " " @ 80 " "					

REMARKS Elements B and C include a 6% insurance against rough handling.

FOREMAN T.S.M. GEN SUPT

FIG. 8.—Master Observation Sheet, showing final data of the box-packing operation outlined in Chap. VII.

With reference to element *A*, it is noted from sheet 1, line 6, that the normal of .075 min. was used. To this a 12 per cent rest factor was added in order to arrive at the .084 min. Allowed Normal.

In element *B*, .104 min., the Allowed Normal, was arrived at in the same manner as for element *A*, except that, since the .030 min. normal was based on one can, it was multiplied by three as specified in the Count Column. Aside from element *C*, the counts for the remaining elements are specified by the figure 1, because they occurred only once during the cycle.

Between the ruled lines near the top of the Master Observation Sheet, a C. Std. of 2.16 min. per box is established as the final allowed time for an operator to pack one box. The 2.16 min. was "boiled down" from the 2.157 min. total. In fact, the standard could be specified as 2.2 min. and by so doing, the 2.157 min. total is increased less than 2 per cent.

One common error that the T.S.M. makes is to specify standards in too many decimal places. For instance, a standard of 3.0997 min. appears very formidable until one realizes that it is only the sum of normals set up from the T.S.M.'s judgment, which is never keen enough to permit of such extended numbers. "Boiling down" 3.0997 min. to 3.1 min. is not only more sensible, but it allows easier slide-rule settings for multiplication and division purposes. Also, where calculating machines are used in office accounting or pay-roll departments, errors are minimized since fewer fingers have to be used on the calculating machines to make the necessary figurations. Therefore, it is advisable to keep C. Standards as short as possible unless the cost department requests differentials of standards in order to recognize individually the closely graduated sizes of the company's products. Of course, C. Standards should not be shortened to the point where accuracy is sacrificed.

With reference again to the 2.16 min. C. Std. in Fig. 8, this allowance is directly used for premium systems. In the case of piecework systems, the production per 80 C. Hour is divided into the hourly rate that is offered as an incentive. For example, if the management established 57 cts. per hour as the ideal wage for an 80 performance, the piecework price of operation 16 would be .57/37 = $.015, piecework price per box. Many

plants specify piecework prices by 100 lots; therefore, in this example, the price would be $1.50 per 100 boxes.

In order that the reader may broaden his conception of many of the points touched upon in this and the previous chapter, another manual operation will be outlined.

The time study to be taken is in a toy factory. A girl operator is assigned to the operation of assembling two small rubber-tired metal disk wheels to a small metal cart body. Since all supplies are taken care of by an indirect worker, the girl operator sits on a stool before her bench where all materials are within arm's reach.

The operation consists first of reaching for one sheet-metal cart body and placing it on a steel plate which is positioned on the bench before her. One disk wheel is then picked up and a long rivet, called the axle, is placed in the disk wheel, after which the rivet is placed in the two small bracket holes in the cart body. The cart is then turned on its side and the other wheel is placed on the axle end. With a light hammer, the operator rivets over the end of the axle. This completes the operation and the operator then places the toy on an inclined chute which conveys it to the next operation. The T.S.M. breaks up the job into the elements as shown on the Shop Observation Sheet in Fig. 9.

Mary Smith is a rapid operator and the T.S.M. finds it difficult to time five of the elements in the regular way. As element *A* is the first very short subdivision, he requests her to perform *A* 10 times in succession. As fast as she reaches for one cart body and places it on the bench plate, the T.S.M. pushes it out of the way; by the time he has done this, the operator has placed another cart body in position on the plate. The T.S.M. has her do this in groups of 10 and each time makes her reach for her work in different parts of the supply pile. Thus, he has timed this short element in groups of 10 and has recognized the slight variations in time due to the operator's picking up work at varying distances from the bench plate. He has the operator repeat this process five times. His timings and ratings are shown in element *A* on the Shop Observation Sheet. The operator was so consistent at her 85R. effective speed that the watch was left running while each group of 10 was being demon-

THE BLANK CORPORATION

SHOP OBSERVATION SHEET

STUDY NO 543 SHEET NO. 1

DATE 5-28-19- PART NO 2731 PART NAME №28-MF CART

OPERATOR MARY SMITH NO 319 OPERATION ASSEMBLE OPER NO 9

NO.	ELEMENT	OPERATION	
1	A	Pick up cart body &	$\frac{.19}{10}-\frac{.21}{10}-\frac{.18}{10}-\frac{.20}{10}-\frac{.18}{10}$ Average @ 85 R = $\frac{.96}{50}$ @ 85 R = .0272
2		place on bench plate.	Av. n
3			
4			
5			
6	B	Pick up axle and one	.04-.04-.06-.05-.04-.05-.03-.05-.06-.04-.05-.06
7		disc wheel & assemble	.04-.06-.03-.05-.05-.04-.06-.05 @ 90 R =
8		in two bearing holes in	.95/20 @ 90 R = .0713 Av n
9		cart.	
10			
11	C	Turn unit on side and	$\frac{.07}{10}-\frac{.07}{10}-\frac{.09}{10}-\frac{.08}{10}-\frac{.09}{10}$ @ 85 R = $\frac{.40}{50}$ @ 85 R = .0113 Av. n
12		assemble other wheel.	
13			
14			
15			
16	D	Rivet over axle end by	$\frac{.43}{10}-\frac{.45}{10}-\frac{.42}{10}-\frac{.45}{10}-\frac{.41}{10}$ @ 80 = $\frac{2.16}{50}$ @ 80 R = .0576 Av. n
17		4 or 5 hammer blows.	
18			
19			
20	E	Spin wheels by hand	.09-.10 @ 55 R-.08-.09-.10-.09-.07-.08-.10-.09-.07
21		to see if free.	.08-.09-.10-.07-.09-.08-.07 @ 80-.09-.08
22			Use average of 55 R & 80 R = $\frac{55+80}{2}$ = 67.5 = $\frac{1.71}{20}$ @
23			67.5 R = .0962 Av. n
24			𝍸 𝍸 𝍸 01101 𝍸 𝍸 00111 𝍸 𝍸 11011 $\frac{5}{50}=\frac{1}{10}$ count
25	F	Rap with hammer to	
26		loosen tight wheels.	.08-.12-.15-.14-.12-.15-.08-.09-.12-.10 @ 85 R = $\frac{1.15}{10}$ @
27			85 R = .164 Av. n
28		See line 24 above for count.	Also remarks below.
29			
30			
31	G	Place finished assembly	$\frac{.20}{10}$ @ 80 R ($\frac{.19 @ 85 R}{10}$ =) .0269 Av. n
32		on incline slide.	
33			
34			
35			
36			

REMARKS Mr. Brown, the foreman, states that count of 1/10 is O.K. because dies are now in average state of wear.

FIG. 9.—A toy-assembly operation.

strated. The average normal of .0272 min. was found by normalizing the .96/50 time and piece factor.

Element *B* was lengthy enough to permit of individual timing. Since the task of passing the axle through the two small bracket holes in the cart body offered a slight variable in time, the varying times were recognized and allowed. The operator was so skillful on this element that a 90R. was given for 20 observations and then averaged after comparing the extremities of the times found. The smallest posting was .03 min. and the largest was .06 min. or twice as long. The T.S.M. reasoned that this 100 per cent spread of time was not abnormal, because there were at least four variables:

1. Pick up axle from mass of supply with one hand.
2. Pick wheel from supply with other hand. 1 and 2 must be done with fingers in exact position for best handling of parts.
3. Dexterity required for placing axle in wheel.
4. Pass axle through two bracket holes.

As judgment advised that the variation of time in element *B* was not excessive in consideration of the work involved, the average of 20 readings was normalized from the 90R. Thus, the normal specified was .0713 min. Av. N.

Since element *C* presented another quick element which was too short to time individually, the T.S.M. lined up 10 units in a row and then had the operator turn each unit on its side. Immediately thereafter, the other wheel was assembled to the upright axle end. The over-all time for the first group of 10, where two were turned over at a time, was .07 min. This was repeated four more times and an average normal of .0113 min. was granted.

With the 10 units still lying on their sides, element *D* was studied. When one group of 10 was finished, 10 more were lined up, etc. The operator used a small riveting hammer with her right hand and with her left hand held a riveting punch, which was placed over each axle end. Four or five firm blows with the hammer riveted the axle end sufficiently to prevent the wheels from coming off. The five different timings are shown on the sheet and, since the extreme readings were within .41/.45 or 91 per cent of each other, the average of the five readings was used, thus giving .0576 min. Av. N. for element *D*.

When the T.S.M. came to element *E*, he was not sure whether the operator was as good on this subdivision as she was on the others. The work consisted of picking up the finished unit with one hand and spinning each wheel separately with the other hand. While doing this, the operator had the habit of looking around the room; hence, the two ratings, 55R. and 80R., were given. The T.S.M. was sure of the second posting of .10 min. for which he granted 55R. and on the eighteenth posting he allowed 80R. for the .07 min. reading. He reasoned that the element was of such character as to be without variation and any fluctuation of time was due to the operator. He normalized the second and eighteenth readings and found he was correct so far as the extremities were concerned. Therefore, he decided to take an average of all the watch readings and normalize them by an average rating. By use of the two averages, he posted .0962 min. as the average normal. The T.S.M. kept a record on line 24 of 50 of the assembled carts. The small lines represented carts that were satisfactory and did not require element *F* treatment. The small circles indicated the carts whose wheels did not freely revolve and would have to be adjusted in the next element. In counting up the lines and circles, he found that out of a total of 50, there were 5 that required adjustment, so 5/50ths or 1/10th of all work required additional work. In talking to the foreman, he learned that the materials were about average, so the count of 1/10th was allowed for the next element.

The adjustment work in element *F* was considered as a variable, but the operator was very cooperative and was given 85R. for all 10 readings, or .164 min. average normal.

As *G* was another element too short to time singly, the T.S.M. lined up 10 finished units and had the operator place them, one at a time, on the inclined chute. The first group of 10 was given 80R., but the second group "clicked" at 85R. The latter was therefore established for normal.

Figure 10 shows the Master Observation Sheet for operation 9, which was prepared by the T.S.M. when he returned to his desk. Some of the legends have been expanded and some condensed. The Reference Column states the exact line in the Shop Observation Sheet on which each normal will be found. The Allowed Externals are the normals, plus rest, times the count.

THE BLANK CORPORATION

MASTER OBSERVATION SHEET

STUDY No. 543

DEPT. NO. 37 DEPT. NAME ASSEMBLY DATE WRITTEN JUNE 2, 19—

PART NO. 2731 PART NAME No. 28MF CART FOR 5 AND 10 TRADE

OPERATION ASSEMBLE TWO WHEELS TO BODY OPER NO 9

MATERIAL SHEET METAL, FROM DIES T391 AND T394

OPERATOR MARY SMITH #319 FEMALE ~~MALE~~ STARTED 6-1-3^{00} P.M. STOPPED 6-1-4^{15} P.M. ELAPSED 1¼ HRS

MACH NO. BENCH MACH NAME

TOOLS SEE SHEET No. 2 FOR TOOLS. SPEED FEED

CREDOR STD .34' PER CART %A I T %N.W T 100%

ELEMENT	REFERENCE	DESCRIPTION OF ELEMENTS	NORMAL	REST	COUNT	ALLOWED EXTERNAL	ALLOWED INTERNAL
A	543-1-1	Pick up cart body & place on bench plate.	.0272	10%	1	.0299	
B	" 1-8	Pick up axle & one wheel & assem. in cart.	.0713	8	1	.0770	
C	" 1-11	Turn unit on side, pick up & assem. other wheel.	.0113	9	1	.0123	
D	" 1-6	Rivet over axle end by 4 or 5 hammer blows	.0576	12	1	.0645	
E	" 1-23	Spin wheels by hand to see if they freely revolve.	.0962	12	1	.1080	
F	" 1-27	Rap with hammer to loosen tight wheels.	.1640	12	$\frac{1}{10}$	.0184	
G	" 1-31	Place finished assembly on incline slide.	.0269	10	1	.0296	
						.3397	
				Use	.34'	C. Std.	
		$\frac{80}{.34}$ = 235 + carts per hour @ 80 Credor Hour					

REMARKS

FOREMAN T S M GEN SUPT

FIG. 10.—Final data of the toy-assembly operation.

For simplification, the C. Std. of .3397 min. was increased by less than 1 per cent and called .34 min. C. Std. The production for an 80 C. Hour shows 235 carts. The toy factory operated on a piecework basis. The management prescribed $15 a week for their 40-hr. working week, or 37½ cts. per hour for this type of female labor. Therefore, the piecework price for operation 9 was $\$.375/235 \times 100 = \$.159$ plus; call it 16 cts. per 100 assembled carts.

It will be noted that on neither the Shop Observation Sheet nor the Master Observation Sheet is space assigned for the question of wages paid to an operator. In an earlier chapter it was explained that a T.S.M. has no power to discuss money matters with operators. Time measurements are the things with which time study deals; rate of pay is determined by the factory management. Wages rise and fall as business conditions change, but C. Standards remain unchanged as long as the operations are not changed.

Questions

1. What is a Credor?

2. On a manual operation, what is the formula for the anticipated production per hour for an 80 operator?

3. Give the formula for obtaining a piecework price per piece, based on rate and production.

Problems

4. You, as T.S.M., have been requested to time-study a short assembly operation in a desk factory. Operation 18 covers the assembly of a metal knob, called the drawer pull, to the front face of the desk drawer.

The desk drawers are brought to Albert Doe by a laborer. The drawers are piled in two stacks 5 to 6 ft. high on a hand truck. The operator must take each drawer, one at a time from the truck supply, and lay it bottom side down on his bench. He must pick up a jig and hang it on the front face of the drawer. The jig consists of a strip of light sheet metal, containing a drill bushing in its center. The jig has two projections on its top edge which centralize and hold it in the proper position.

The operator then picks up an electrically driven power drill carrying a twist drill and positions the latter in the drill bushing. While this is being done, he snaps a switch which starts the drill revolving at a fast speed. The drilling of the hole in the ¾ inch thick wooden member of the drawer face is a short element. The hole is a pilot hole for the wood screw.

The operator next picks up a small metal drawer pull which has a hole through its center. At the same time, he picks up a wood screw from a supply box and also a screw driver. The assembly of the screw requires several turns of the screw before it holds the drawer pull firmly in position.

THE BLANK CORPORATION

SHOP OBSERVATION SHEET

STUDY NO. 3672 SHEET NO. 1

DATE MAY 27, 19– PART NO D48-3 PART NAME STYLE D OFFICE DESK

OPERATOR ALBERT DOE NO. 18-97 OPERATION ASSEMBLE CENTER DRAWER PULL OPER. NO. 18

NO	ELEMENT	OPERATION	HIGH	AVERAGE	LOW
1	A	Place one drawer from	.05 .06 .07 .06 .05	.04 .05 .04 .04 .05	.04 .05 .04 ~~.06~~ .03
2		truck on bench.	.06 .06 .05 .05	.04 .04 .03 .05 .04	.05 .06 ~~.10~~ .05
3			.06 @ 80 R	@ 80 R	.04 @ 60 R
4					
5					
6					
7	B	Place jig on front face	.06 .06 .05 .06 .05 .05		
8		of drawer.		Call .055 @ 75 R =	
9					
10	C	Position and start	.08 @ 60 R .10 @ 50 R	.11 @ 45 R	.07 @ 70 R
11		electric drill.	.08 @ 60 R .08 N		
12					
13					
14					
15					
16	D	Drill one 3/32 hole thru	.05 .04 .04 @ 80 R		
17		3/4 drawer face.			
18					
19					
20	E	Away electric drill &	.12 .12 .15 .14 .12 .10 .12 .11 .13 .12		
21		remove jig. 75 R			
22					
23					
24	F	Pick up drawer pull,	.09 .09 .08 .09 .09 .10 .10 .08 .09 .10 @ 60 R		
25		one screw & screw-driver			
26					
27					
28					
29	G	Drive home screw &	.16 .19 .23 .19 @ 60 R .17 .21		
30		lay down screw-driver.			
31					
32					
33	H	Place finished drawer	~~.12~~ ~~.15~~ ~~.18~~ See Part M48-7 for normal		
34		on other truck.			
35			TS3665-3-24 Use .087 N.		
36					

REMARKS

FIG. 11.—Unfinished Shop Observation Sheet relating to Prob. 4. Use the duplicate for figuration.

THE BLANK CORPORATION
SHOP OBSERVATION SHEET

STUDY NO. 3672 SHEET NO. 1

DATE MAY 27, 19— PART NO D48-3 PART NAME STYLE D OFFICE DESK

OPERATOR ALBERT DOE NO. 18-97 OPERATION ASSEMBLE CENTER DRAWER PULL OPER. NO. 18

NO	ELEMENT	OPERATION	HIGH	AVERAGE	LOW
1	A	Place one drawer from	.05 .06 .07 .06 .05	.04 .05 .04 .04 .05	.04 .05 .04 ~~.08~~ .03
2		truck on bench.	.06 .06 .05 .05	.04 .04 .03 .05 .04	.05 .06 ~~.10~~ .05
3			.06 @ 80 R	@ 80 R	.04 @ 60 R
4					
5					
6					
7	B	Place jig on front face	.06 .06 .05 .06 .05 .05		
8		of drawer.	Call .055 @ 75 R =		
9					
10	C	Position and start	.08 @ 60 R .10 @ 50 R .11 @ 45 R .07 @ 70 R		
11		electric drill.	.08 @ 60 R .08 N		
12					
13					
14					
15					
16	D	Drill one 3/32 hole thru	.05 .04 .04 @ 80 R		
17		3/4 drawer face.			
18					
19					
20	E	Away electric drill &	.12 .12 .15 .14 .12 .10 .12 .11 .13 .12		
21		remove jig. 75R			
22					
23					
24	F	Pick up drawer pull,	.09 .09 .08 .09 .09 .10 .10 .08 .09 .10 @ 60 R		
25		one screw & screw-driver			
26					
27					
28					
29	G	Drive home screw &	.16 .19 .23 .19 @ 60 R .17 .21		
30		lay down screw-driver.			
31					
32					
33	H	Place finished drawer	~~.12~~ ~~.15~~ ~~.17~~ See Part M48-7 for normal		
34		on other truck.			
35			TS3665-3-24 Use .087 N.		
36					

REMARKS

Duplicate FIG. 11.—To be used by the reader for the figuration of Prob. 4.

In the last item of work, the operator picks up the finished drawer, walks about 4 ft., and stacks it neatly on a separate truck.

After analysis, you have split up the operation into elements as shown on the Shop Observation Sheet bearing time-study number 3672. You have timed and rated several cycles and are now ready for normalizing. Your remaining task for each element *A* to *H*, inclusive, is outlined as follows:

Element A.—Realizing that it would be unfair to measure this element from a very few observations, you have split up this work into three classes: High, Average, and Low. It was found that it took longer to procure a drawer from the top of the stack on a fresh supply truck than it did to get one from a nearly empty truck, hence the three divisions of timings. The operator was cooperative on the High and Average divisions and so you gave him ratings of 80R. each and computed your partial figuration from them. However, the operator, in selecting drawers from the Low, or easiest location, fumbled around so much that you reduced his ratings to 60R. and struck out two abnormal readings, after which you normalized the remainder.

Question: What is your final averaged normal, carried to three decimal places?

Element B.—The timings on this ran very even and you decided to normalize at .055 min.

Question: What is the normal, carried to three decimals?

Element C.—The operator was "all over the lot" on this work, but you were able to prescribe ratings for the five watch readings and, after normalizing each, you averaged the normals. (One normal is shown.)

Question: What is the final averaged normal, carried to three places?

Element D.—You timed two elements and were not sure of your ratings for them, so you merely posted the two timings. The third timing "clicked" and therefore you used it.

Question: What is the normal, carried to three places?

Element E.—The operator was fairly cooperative on this, but you felt you had better select the watch reading that occurred the greatest number of times and normalize it.

Question: What is the normal, carried to three places?

Element F.—You could not conscientiously give the operator over 60R. for this work, so you averaged all 10 readings and converted at 60R.

Question: What is the final averaged allowed normal, carried to three decimal places?

THE BLANK CORPORATION
MASTER OBSERVATION SHEET

STUDY No. 3672

DEPT. NO 18 DEPT. NAME FINISHING DATE WRITTEN JUNE 4, 19–

PART NO PART NAME

OPERATION OPER NO

MATERIAL SEE B/P D48-3

OPERATOR FEMALE MALE STARTED 6-1-2³⁰ STOPPED 6-3-2¹⁵ ELAPSED $1\frac{1}{4}$ HRS

MACH. NO. MACH NAME

TOOLS JIG T312 $\frac{3}{32}$" CARBON STEEL STRAIGHT SHANK TWIST DRILL. STYLE F ELECTRIC DRILL. HAND SCREW DRIVER WITH $\frac{1}{4}$" BLADE. SPEED FEED

CREDOR STD PER DRAWER %A I T %N.W.T 100%

ELEMENT	REFERENCE	DESCRIPTION OF ELEMENTS	NORMAL		REST	COUNT	ALLOWED EXTERNAL		ALLOWED INTERNAL	
A					12%	1				
B					12	1				
C					14	1				
D					14	1				
E					12	1				
F					10	1				
G					15	1				
H					13	1				

REMARKS

FOREMAN T S M GEN SUPT

FIG. 12.—Unfinished Master Observation Sheet relating to Prob. 5. Use the duplicate for figuration.

THE BLANK CORPORATION

MASTER OBSERVATION SHEET

STUDY No. 3672

DEPT. NO 18 DEPT. NAME FINISHING DATE WRITTEN JUNE 4, 19-

PART NO PART NAME

OPERATION OPER NO

MATERIAL SEE B/P D48-3

OPERATOR FEMALE MALE STARTED 6-1-2^{30} STOPPED 6-3-2^{15} ELAPSED $1\frac{1}{4}$ HRS

MACH. NO. MACH NAME

TOOLS JIG T312 $\frac{3}{32}$" CARBON STEEL STRAIGHT SHANK TWIST DRILL. STYLE F. ELECTRIC DRILL. HAND SCREW DRIVER WITH $\frac{1}{4}$" BLADE. SPEED FEED

CREDOR STD PER DRAWER %A I T %N.W.T 100%

ELEMENT	REFERENCE	DESCRIPTION OF ELEMENTS	NORMAL		REST	COUNT	ALLOWED EXTERNAL		ALLOWED INTERNAL	
A					12%	1				
B					12	1				
C					14	1				
D					14	1				
E					12	1				
F					10	1				
G					15	1				
H					13	1				

REMARKS

FOREMAN T S M GEN SUPT

Duplicate FIG. 12.—To be used by the reader for the figuration of Prob. 5.

Element G.—You "saw" the fourth posting at 60R.

Question: What is the normal, carried to three decimal places?

Element H.—This element was a "sleigh ride" and, after timing three cycles, you decided to cross them all out and use a similar element timing from T.S. 3665, which covered another operator the previous day on an operation almost exactly like the present one. Later, when you returned to the time-study department, you looked up this study and granted .087 min. for the normal.

NOTE: Because of the fact that the foregoing normals are used in the next problem, it is revealed that the total of the normals you specified for all elements, *A* to *H*, inclusive, is .780 min. This information will enable you to check back over your work before you begin Prob. 5, using duplicate Fig. 11 for the figuration.

5. Using duplicate Fig. 12, fill in all the unfilled spaces above and below the double-ruled lines. The necessary information is supplied by the Shop Observation Sheet for T.S. 3672. The normals you have set up on that latter sheet are to be posted to the Master Observation Sheet and extended by the rest factors that are listed for each of the elements. What is the C. Std. per drawer? (Show C. Std. to two decimal places.) What is the production per hour @ 80 C. Hour?

Answers to Questions

1. A Credor is a minute's worth of work, containing part labor and part rest, each of which may vary in proportion, but the sum of which always equals unity.

2. $\frac{\text{80 min.}}{\text{C. Std.}}$ = production per hour (manual operation)

3. $\frac{\text{Hourly wage to be paid}}{\text{Production per hour @ 80 C. Hour}}$ = piecework price per piece

Answers to Problems

4. Figure 13 contains the Shop Observation Sheet in which the correct normals appear for all elements.

5. Figure 14 shows the correctly finished Master Observation Sheet for Prob. 4. As shown therein, the Credor Standard, carried to two decimal places, is .88 min. and the 80 C. Hour production is 91 drawers.

The Started space shows June 1 at 2:30 P.M. and the Stopped space shows June 3 at 2:15 P.M. Since the Elapsed space shows only 1¼ hr., it is evident that the study was spread over 2 or 3 days.

The Reference Column shows the various lines referred to on the Shop Observation Sheet. Whenever a time study consists of only one or two Shop Observation Sheets, the references can be dispensed with. It is on long, involved studies that the advantages of the reference items are felt.

THE BLANK CORPORATION

SHOP OBSERVATION SHEET

STUDY NO. 3672 SHEET NO. 1

DATE MAY 27, 19– PART NO. D48–3 PART NAME STYLE D OFFICE DESK

OPERATOR ALBERT DOE NO. 18–97 OPERATION ASSEMBLE CENTER DRAWER PULL OPER NO. 18

NO.	ELEMENT	OPERATION	HIGH	AVERAGE	LOW
1	A	Place one drawer from	.05 .06 .07 .06 .05	.04 .05 .04 .04 .05	.04 .05 .04 ~~.08~~ .03
2		truck on bench.	.06 .06 .05 .05	.04 .04 .03 .05 .04	.05 .06 ~~.10~~ .05
3			.06 @ 80 R =	@ 80 R =	.04 @ 60 R = 36/8
4			57/10 @ 80 R = .076′ N	42/10 @ 80 R = .056′ N	@ 60 R = .045′ N
5			~~$\frac{.076 + .056 + .045}{3}$ = .059′ av. N~~		
6					
7	B	Place jig on front face	.06 .06 .05 .06 .05 .05		
8		of drawer.	Call .055 @ 75 R = .069′ N		
9					
10	C	Position and start	.08 @ 60 R 10 @ 50 R 11 @ 45 R .07 @ 70 R 08 @ 60 R		
11		electric drill.	.08′ N .083′ N .0825′ N .0817′ N .08′ N =		
12			407/5 = .081′ av. N		
13					
14					
15					
16	D	Drill one 3/32 hole thru	.05 .04 .04 @ 80 R = .053′ N		
17		3/4 drawer face.			
18					
19					
20	E	Away electric drill &	.12 .12 .15 .14 .12 .10 .12 .11 .13 .12		
21		remove jig. 75 R	Call .12 @ 75 R = .15′ N		
22					
23					
24	F	Pick up drawer pull,	.09 .09 .08 .09 .09 .10 .10 .08 .09 .10 @ 60 R		
25		one screw & screw-driver	.91/10 @ 60 R = .091′ N		
26					
27					
28					
29	G	Drive home screw &	.16 .19 .23 .19 @ 60 R .17 .21		
30		lay down screw-driver.	.19′ N		
31					
32					
33	H	Place finished drawer	~~.12~~ ~~.15~~ ~~.17~~′ See Part M48-7 for normal		
34		on other truck.	for placing work on truck.		
35			TS 1984-3-24 Use .087′ N		
36					

REMARKS

FIG. 13.—Completed Shop Observation Sheet relating to Prob. 4.

THE BLANK CORPORATION
MASTER OBSERVATION SHEET

STUDY No. 3672

DEPT NO 18 DEPT. NAME FINISHING DATE WRITTEN JUNE 4, 19–

PART NO D48-3 PART NAME STYLE D OFFICE DESK

OPERATION ASSEMBLE CENTER DRAWER PULL OPER. NO 18

MATERIAL SEE B/P D48-3

OPERATOR 18-97 ALBERT DOE ~~FEMALE~~ MALE STARTED 6-1-2 30 STOPPED 6-3-2 15 ELAPSED 1¼ HRS.

MACH NO MACH NAME

TOOLS JIG T312 3/32" CARBON STEEL STRAIGHT SHANK TWIST DRILL. STYLE F ELECTRIC DRILL HAND SCREW DRIVER WITH 1/4" BLADE. SPEED FEED

CREDOR STD .88 PER DRAWER %A.I.T %N W T 100%

ELEMENT	REFERENCE	DESCRIPTION OF ELEMENTS	NORMAL	REST	COUNT	ALLOWED EXTERNAL	ALLOWED INTERNAL
A	3672-1-5	Place one drawer from truck on bench.	.059	12%	1	.0661	
B	" 1-8	Place jig on front face of drawer	.069	12	1	.0773	
C	" 1-12	Position and start electric drill	.081	14	1	.0923	
D	" 1-16	Drill one 3/32" hole through 3/4" drawer face.	.053	14	1	.0604	
E	" 1-21	Withdraw electric drill and remove jig.	.150	12	1	.1680	
F	" 1-25	Pick up drawer pull, one screw & screw driver.	.091	10	1	.1000	
G	" 1-30	Drive screw home & lay down screw driver	.190	15	1	.2185	
H	" 1-35	Place finished drawer on other truck.	.087	13	1	.0983	
						.8809	
			Use	.88'	C.Std.		
		$\frac{.80}{.88}$ = 91 drawers per hour @ 80 Credor Hour					

REMARKS

FOREMAN T S M GEN SUPT

FIG. 14.—Completed Master Observation Sheet covering Prob. 5 requirements.

Chapter IX

In this chapter, a distinction is made between machines which are entirely manually operated and machines which have power feeds. For the latter a % N.W.T. (Per Cent Normal Working Time) factor is established. By means of this factor, the T.S.M. knows how much of the operator's time is consumed during the machine cycle and thus what percentage of time is available for other duties. Chapter XII further stresses the application of the % N.W.T. factor in multiple-machine assignments or in making other use of the operator's leisure time during cycles.

CHAPTER IX

BUILDING STANDARDS ON MACHINE OPERATIONS

The timing of manual elements for machine operations is handled in the same fashion as for elements in manual operations, except that particular attention is paid to classify them either as Externals or Internals. It has been previously explained that Externals do and Internals do not influence the cycle lengths in regular machine operations.

Figures 3 and 4, in Chap. VI, show M.T. incorporated in a cycle. The M.T. is now expanded into two fundamental groups of machine times, which are

1. H.M.T. = Hand-controlled Machine Time.
2. P.M.T. = Power-controlled Machine Time.

Hand-controlled Machine Times occur on power-driven machines where the operator, by his direct effort, sets the pace and, consequently, controls production. In other words, when a machine requires an operator to hand-feed it, the performance is known as H.M.T. On machines of this class, there are no Internals, because the operator is as busy on H.M.T. elements as he is on manual ones. A few examples of machines where H.M.T. is in use are as follows:

Hand-feed drill press. Operator must pull lever or turn feed wheel to assist the machine.

Hand milling machine. Operator pulls lever to assist the machine.

Polishing machine. Operator must manipulate work for its completion.

Grinding stand. Operator's own efforts sharpen tools or grind the work.

Band saw. Carpenter determines production.

Foot-operated power press. Operator controls output.

H.M.T. operations are about the hardest kind of work to time and rate. The T.S.M. must determine to what degree the operator's effort impels the machine's proper efficiency. One way of doing this is to check the actual times by formulas applying to the work. In the foregoing list, the hand-feed drill press is subject to the same formulas as the regular type of

power-feed machines. Handbooks give the proper speeds and feeds to be used for various sizes of drills for different materials being machined. An 80 rating is given to a machine when it is running at the correct speed and feed and is producing work whose quality, accuracy, and costs are satisfactory. If, for example, watch readings for the H.M.T. elements on a particular hand-feed drill press, represent only 85 per cent of the machine efficiency based on machine time computed from a formula, the rating to be allowed the operator for his effort is

$$85 \text{ per cent} \times 80\text{R.} = 68\text{R.}$$

Milling machines that operate by hand feed are also subject to various cutting speeds and feeds, which may be obtained from handbooks. Some of the formulas for milling cutters specify the feet or inches per minute for suitable cutting action. Information is available covering the amount of metal each tooth in the milling cutter should remove. Therefore, hand-fed milling cutters can be checked with data pertaining to power-fed cutting action.

Polishing operations are another hard type of H.M.T. operations to time and rate. First of all, a sympathetic and cooperative operator should give the demonstrations. The snap-back watch method permits of having the polishing operator perform his work on certain spots on a piece of work, after which the piece is laid down and another piece receives that same treatment. Thus, the cycle is obtained from work polished in sections. The same operations should be demonstrated by different operators in order to feel sure that timings and ratings are correct.

Hand-grinding jobs offer another case where the T.S.M. must be unusually alert. Sparks fly from work being ground even though the work is barely touching the grinding wheel. However, a trained observer can measure the effect of the effort being displayed by the volume of sparks evidenced and also by the energy shown by the operator on his task.

This brings up the question of the status of tools used on H.M.T. elements. Tools, cutters, polishing disks, grinding wheels, files, chisels, hack-saw blades, etc., should be neither new nor old and neither dull nor freshly sharpened when studies are made. It would be manifestly unfair to study a bench hand who has a prolonged filing operation and insist that he use a

brand-new file. A half-worn file should be used for the demonstration, because it is in average condition and the retarded action caused by a dull file is offset by the faster cutting action of a new one. The T.S.M. is establishing a suitable time allowance to complete each element in a cycle and so he must set up time values that can be met. This means that the condition of the tools should be investigated before studies are started.

There are many hand-controlled machines of such character as to render direct timing unnecessary. Instead, indirect measurements are secured. This practice can be followed on machines doing a simple type of work where all duties are Internal and the machine yields a large amount of production as a result of its continuous operation throughout the day. Preparation and incidental work are time-studied to learn the net working hours per day for the machine, and efficiency factors are established for the proper machine output. An illustration of this indirect measurement method is cited in a paper-box manufacturing plant on one of its wrapping machines.

Several of these wrapping machines were in operation and the management felt that the production costs from them were too high. The T.S.M. spent considerable time on the analysis and observation of them. Demonstrations were made by one of the most skilled girl operators, because an even performance simplified the tests which were made.

The speed of one of the wrapping machines was increased a little each day until it made 19.6 strokes per minute. At this speed the skilled operator could catch every stroke of the press without exception. For this sustained work she was given a rating of a 90 C. Hour.

All work was Internal beyond the oiling of the machine twice daily, filling glue tank, certain minor cleaning of the machine, and other small items of work, the total of which amounted to 20 min. per day. The plant operated on a 10-hr. working day; therefore, the net operating wrapping machine time was 600 min. minus 20 min., or 580 machine-working min. per day. The theoretical daily production on that basis should have been $580 \times 19.6 = 11{,}368$ boxes per machine, but of course this ideal figure was not met. A test was run for 1 day and the output of all boxes, both good and bad, was carefully counted. The

operator, although not timed, was continually observed to see if she justified a sustained 90 C. Hour.

At the end of the day's test, the actual production of both good and bad boxes was 11,100, which signalized a consistent endeavor. 11,100/11,368 = 97.6 per cent efficiency in the operator's capacity. It was decided to increase this percentage slightly and call it 98.2 per cent required capacity for a 90 C. Hour.

Next, the bad boxes were inspected. Out of the 11,100 boxes produced, 10,812 were good. Out of the 288 bad boxes, the inspectors felt that 54 of them were spoiled because of carelessness and that 10,866 good boxes should have been made. Therefore, 10,866/11,100 = 97.9 per cent—call the quality factor 98 per cent. Thus, 98.2 per cent operating and 98 per cent quality factors were set up for the 90 C. Hour operator.

Based on the theoretical production, the day's output was set up as follows:

11,368 × 98.2 per cent effort × 98 per cent quality = 10,940 good boxes from one machine in 10 hr.

90 C. Hour × 10 hr. = 900 Credors per day credited to the operator for her sustained effort

$$\frac{900}{10{,}940} \times 100 = 8.23 \text{ C. Std. per 100 boxes}$$

The other less skilled operators were not able to average more than 9,850 boxes per day, so their efficiency was

$$\frac{9{,}850 \times .0823}{10 \text{ hr.}} = 81.1 \text{ C. Hour average, in comparison to the skilled operator's 90 C. Hour.}$$

The foregoing method of arriving at C. Standards on machines takes into account the operator's skill as well as the machine's potential capacity and also embraces the question of quality of work. In cases of this kind, the rating, which includes rest and therefore is a Credor-hour rating, must be considered from the angle of constant effort. The effort and quality percentage factors must be thoroughly analyzed before applying. If the operator had been erratic, a record would have been kept of the missed machine strokes and either the ratings or net working-day

minutes would have been adjusted to account for varying performance of the work.

Power Machine Times accrue from machines of such design that after the operator has started the machine and engaged the feed, the machine is self-supporting during the element and completes its work without physical assistance from him. Of course, the operator must give periodical attention to the machine in order to insure its correct function, but this attention factor is always an Internal element.

It is a simple job to time P.M.T. elements, because the over-all time of the element is merely posted without accompanying ratings. No ratings are necessary by reason of the fact that the machine produces at an 80 C. Hour and the Internal work which the operator performs during the P.M.T. does not affect the machine's productivity. This statement is made on the premise that the machine has been "tuned up" and is producing as it should for best results. Thus, while the machine is actually producing without the aid of the operator, the machine is earning 80 Credors per hour, which is the ideal accomplishment for both man and machine.

All watch readings of P.M.T. should be checked against formulas applicable to the machine. The procedure for this is the same as for H.M.T. Any differences between the actual and calculated times should be investigated and steps should be taken to correct the differences. Often machines are overloaded. If this condition cannot be alleviated, a percentage factor is added to the machine times. This percentage factor is usually approximately 5 per cent. In no case should more than 10 per cent be added for variance of power or for "cutting air." The life of a machine is materially shortened by overloading and it is a part of the duties of a T.S.M. to see that machines receive careful treatment.

Time-study work does not always speed up machines. There are frequent occasions when machines should be slowed down for greater output. Where a machine is operating at its maximum limit, tool grinding is excessive and the machine is stopped too often for repairs and adjustments. The T.S.M. should analyze the conditions and slow the machine down to the point where it is not only producing more cheaply but is operating with less wear.

In certain types of machine operations there are combinations of H.M.T. and P.M.T. These are the instances where the operator disengages the power feed and finishes the end of the element by hand feed. For example, a lathe tool under power feed is approaching a precise section of the work and the lathe hand throws out the feed and continues the cut by hand feed in order to make sure the exact stopping point is not overrun. No set rule can be laid down for combinations of hand- and power-controlled machine times. Usually the former occupies so little of the machine time that it is consolidated with the power-controlled machine-feed time. Where it is an important item, the H.M.T. should be established as a separate element that occurs immediately after the P.M.T.

The use of a second stop watch often helps the T.S.M. to shorten the period of time spent in studying a machine operation. While one watch is recording the P.M.T., the second watch can be used to pick up Internals.

Machine operations are generally more involved than manual ones on account of the suboperations attached to machine work. These suboperations include such things as setups, preparation work, tool changes, etc. Since a setup operation is almost always considered as a separate timing job, it will be outlined in a subsequent chapter.

Preparation work covers oiling of the machine, arranging equipment and work for best handling, cleaning away chips, getting initial production inspected, filling lubricant cans, and many other items that cannot be classified as regular operational elements. All preparation work must be analyzed, timed, and rated in the same manner as regular elements.

There are instances where preparation work has its own individual C. Standards. This occurs where, after an official setup has been made, the oiling of the machine requires considerable time and other intermediary work becomes necessary before the actual production starts on small quantities of work. For example, on a large machine that has so many oil cups that it requires 10 or 15 min. per day to oil all of them thoroughly, it would not be fair to incorporate that time in a C. Std. covering a piece of work which is made in lots of two or three pieces and which, perhaps, can be completed in less than 1 hr. If the machine is in use all day, all standards cannot carry the excessive

preparation time, because these suboperations do not apply to all different jobs handled throughout the day. In conditions of this kind, the preparation work carries a separate C. Std., which enables the operator to make extra money. The cost department recognizes these standards as excess cost or indirect C. Standards.

On work whose quantity of pieces per lot allows a day's run of production, the preparation work can be absorbed in the regular C. Std. per piece. Where the preparation work is negligible, the timing of it can be dispensed with by adding a small percentage factor to the total allowed times. The percentage should never be guessed, even though it is quite small. This will be discussed in the various problems outlined hereafter.

Not only should the T.S.M. time the grinding of all tools but he should find out how many pieces of work are produced between grinds. The tool grinding allowance per cycle is embodied in the total time allowed; in fact, all incidental work surrounding some given job must be recognized and disposed of in a definite way.

The production per hour obtained from an H.M.T. cycle is found by means of the C. Std. in the same manner as for manual operations. However, the production from P.M.T. operations must be figured from another formula, which is

$$\frac{\text{60 min. per hour}}{\text{Cycles length in minutes}} = \text{production per hour}$$

The cycle consists of the sum of the External elements (reduced to an 80 basis) plus the P.M.T. The reader will recall that all watch readings are normalized to the 60 basis to allow for the average speed of an average worker. To arrive at the anticipated production, we must reduce the Externals to an 80 basis. This is done by multiplying the sum of the Externals by .75, which is known as R.F. or the Reduction Factor. The formula now becomes

$$\frac{\text{60 min.}}{\text{Total Externals} \times .75 + \text{P.M.T.}} = \frac{\text{60 min.}}{\text{cycle}} = \text{production per hour}$$

The reduction factor is 60/80ths or 75 per cent, hence its application to normalized Externals when cycle lengths are computed.

It has been stated that the M.T. as indicated by the stop watch should be checked against the calculated machine times found from formulas. Although this book is intended to cover all fields of manufacturing, space does not permit the listing of the various formulas encountered in each separate industry.

The majority of machines in use, regardless of the product made, finish work by means of a cutting action. This cutting action may be done by grinding wheels, drills, knives, saws, cutters, diamonds, or tools suitable for the removal of stock, which thereby converts the material from the rough to the finished state. The materials which are worked may be metal alloys, wood, paper, cloth, stone, rubber compositions, etc.

The cutting action is generally based on cutting feet per minute and a feed which continues the cutting action until the work is partially or wholly finished. F.P.M. has, as one factor, the diameter of the revolving tool or of the work. The other factor is the number of revolutions made per minute by the moving part.

To illustrate F.P.M., let us assume that a man is pushing a cart along a road. The larger the wheels on the cart, the greater the distance the cart moves forward in one complete revolution of the cart wheels. Also, the faster the cart is propelled, the more revolutions per minute the cart wheel will make and, consequently, the greater distance in feet traveled per minute. The formula for F.P.M. as given by handbooks is

$$\text{F.P.M.} = \frac{D \times 3.1416 \times \text{r.p.m.}}{12}$$

where F.P.M. = feet per minute
D = diameter in inches of revolving part
r.p.m. = revolutions per minute made by the revolving tool or the work.

Example.—Assume that the tires on your automobile are 35 in. on their outside diameter and that you have regulated the engine to cause the wheels to revolve 150 times per minute. How many feet per minute at this r.p.m. does your car travel?

Solution:

$$\frac{35 \text{ in.} \times 3.1416 \times 150}{12} = 1{,}374.5 \text{ F.P.M., answer}$$

The foregoing formula can be condensed for your slide-rule figurations by setting up a constant for the circumference and foot factors. The constant

is 12/3.1416 = 3.82, which is close enough for slide-rule data. The slide-rule setting becomes

$$\frac{C}{D}\ \left|\ \frac{\text{Set diameter in inches}}{3.82}\ \right|\ \frac{\text{Read F.P.M.}}{\text{Over r.p.m.}}$$

The formula can be transposed for cases where the F.P.M. is known and the r.p.m. is desired.

$$\text{R.p.m.} = \frac{\text{F.P.M.} \times 12}{D \times 3.1416}$$

Example.—A factory has purchased a tool-grinding stand upon which tools are to be sharpened. The grinding wheels are 18 in. in diameter and must be belted up to grind work at 5,000 F.P.M. What is the required r.p.m.?

Solution:

$$\frac{5{,}000 \text{ ft.} \times 12}{18 \times 3.1416} = 1{,}060 \text{ r.p.m., answer}$$

The diameters referred to in the formula given above are the effective diameters. For illustration: Suppose a machinist is given the job of boring a 1½-in. hole in a 24-in. diameter cast-iron pulley. He selects the lathe speed suitable for the hole diameter and not the outside diameter. Further, suppose he decides that he should bore the hole at the rate of 70 F.P.M. The selected speed of the lathe will be

$$\frac{70 \times 12}{1.5 \times 3.1416} = \frac{840}{4.71} = 178 \text{ r.p.m.}$$

If the machinist was next called upon to turn the outside diameter of the pulley at 70 F.P.M., he would select the speed suitable for the effective outside diameter, which in this case would be 24 in. plus the stock removed. Assuming that there was ¼ in. to be removed, the effective diameter would be 24½ in. and he would select the nearest speed to 10.9 required r.p.m.

The feed specified for a machine is the means of keeping the cutting action effective. The feed data for metal-shaping machinery in machine shops usually covers the tool advance per revolution of work. Thus, .008 in. feed required for a twist drill signalizes that the feeding mechanism of the machine must be set to cause the drill to advance .008 in. in distance into the work for every revolution it makes.

Feed data is often specified for so many inches per minute. This means that the combination of r.p.m. and feed must be such as to travel at the inches per minute requested. Thus, if 9.8 in. is specified for a milling machine operation, the first step

is to establish the r.p.m. of the milling cutter for its desired cutting action and then divide the r.p.m. into 9.8 in. in order to find the feed per revolution necessary to insure the inches-per-minute performance.

The combination of revolutions per minute, feed, and the length of cut is used to determine the time element. The usual machine-shop formula for this is

$$T = \frac{L}{f \times \text{r.p.m.}}$$

where T = time in minutes
L = length of cut in inches
f = feed per revolution of work or tool
r.p.m. = revolutions per minute of work or tool.

Carrying on the pulley hole-boring example on page 169, the machinist sets his lathe to run 178 r.p.m. The hole is 5¼ in. long and he uses .018 in. feed per revolution of the work. The calculated time is

$$\frac{5.25}{178 \times .018 \text{ in.}} = 1.64 \text{ min. P.M.T.}$$

If a study had been taken of this lathe operation, the watch readings for the P.M.T. should have come within 5 per cent of the calculated time of 1.64 min.

The % N.W.T. space on the Master Observation Sheet means the Per Cent Normal Working Time per machine minute that is required by an operator to complete each cycle of work. On manual and H.M.T. operations, the % N.W.T. is 100 per cent. On P.M.T. operations, the operator usually has available idle time that can be utilized for other duties. The % N.W.T. is computed from the following formula:

$$\% \text{ N.W.T.} = \frac{Te + Ti}{C}$$

where Te = sum of External minutes reduced to 80 basis
Ti = sum of Internal minutes reduced to 80 basis
C = cycle length in minutes = Te + P.M.T.

Example.—In a tractor factory, a boring-mill operator is studied. The sum of the allowed Externals is 7.66 min. while the sum of the Internals amounts to 18.2 min. The total actual P.M.T. is 36.75 min. What is the % N.W.T.?

Solution:

$$\begin{aligned} Te &= 7.66 \text{ min.} \times .75 \text{ R.F.} &&= 5.75 \text{ min. @ 80 C. Hour} \\ Ti &= 18.2 \text{ min.} \times .75 \text{ R.F.} &&= 13.65 \text{ min. @ 80 C. Hour} \\ C &= 5.75 \text{ min.} + 36.75 \text{ min.} &&= 42.5 \text{ min. cycle length.} \end{aligned}$$

$$\frac{Te + Ti}{C} = \frac{5.75 \text{ min.} + 13.65 \text{ min.}}{42.5 \text{ min.}} = \frac{19.4 \text{ min.}}{42.5 \text{ min.}} = 45.6\% \text{ N.W.T., answer}$$

Thus, the operator is only 45.6 per cent busy on the boring mill when he performs his manual elements at the rate of 80 C. Hour. The C. Std. for this job would be 7.66 min. + 18.2 min. = 25.86 min., call 26 min. C. Std. The production per hour obtained from the standard is 60/42.5 = 1.41 pieces.

A shorter formula is recommended for regular use. It reconciles standards that are modified or production per hour that is reflected to less significant figures. The formula is

$$\% \text{ N.W.T.} = \frac{\text{C. Std.} \times \text{hourly production}}{80} = \frac{\text{Credors per hour}}{80}$$

If this last formula is applied to the boring-mill operation, it will be found that, since the C. Std. was raised less than 1 per cent, it will reflect a slightly greater % N.W.T.

$$\frac{26 \times 1.41}{80} = 45.8\% \text{ N.W.T.}$$

The % N.W.T. factor should be carried to at least one decimal place to the right of the decimal, as in the above example. Raising or lowering this factor appreciably causes serious errors in figuration.

Figure 15 covers a Master Observation Sheet made out for a lathe operation in a gasoline-engine plant. The Shop Observation Sheets, although referred to, are not presented. The unusual features of any elements that have not been previously explained will receive comment.

When the T.S.M. was notified that the operation was in readiness for study, he saw that only one each of arbor, dog, and tool was in use and, as a result of this condition, several of the elements were performed externally. He requested another set of the desired tool equipment and had the toolroom grind the spare tool, since the nearest grinding stand was about 125 ft. away from the lathe. The job was then "tuned up" on the new basis and elements were specified as recapitulated in Fig. 15.

THE BLANK CORPORATION
MASTER OBSERVATION SHEET

STUDY No. 339

DEPT. NO. 47 DEPT. NAME LATHE DATE WRITTEN

PART NO. 34 RR G7-3 PART NAME MAIN DRIVING GEAR

OPERATION TURN O.D. AND FACE ONE SIDE OF O.D. RIM OPER. NO. 3

MATERIAL SEMI-STEEL. PATTERN 34RRFG7-3

OPERATOR 47-69 THOMAS DOE ~~FEMALE~~ MALE STARTED 10/1 3:15 STOPPED 10/1 5:00 ELAPSED 1¾ HRS.

MACH. NO. 228 MACH. NAME 14"X6' LODGE & SHIPLEY ENGINE LATHE

TOOLS SNAP GAGE T1991 - TWO 1¼ ARBORS & DOGS. SPEED 66 RPM 75.6 F.P.M.
TWO ROUND NOSE ⅝ X 1¼ LATHE TOOLS. FEED .022"
PORTABLE ARBOR PRESS.

CREDOR STD. PER GEAR %A.I.T. %N.W.T.

ELEMENT	REFERENCE	DESCRIPTION OF ELEMENTS	NORMAL	REST	COUNT	ALLOWED EXTERNAL	ALLOWED INTERNAL
A	339-1-3	Pick up gear & place on arbor press.	.080	10			.088
B	" 1-7	Insert arbor & set arbor press ram.	.110	11			.122
C	" 1-12	Press arbor into gear blank.	.128	18			.151
D	" 1-15	Place on & tighten driving dog.	.093	12			.104
E	" 1-19	Clean & oil arbor centers.	.267	10			.294
F	" 1-24	Lay loaded arbor on end of lathe.	.090	10			.099
G	" 1-28	Pick up loaded arbor & place on lathe centers	.071	12		.080	
H	" 1-33	Adjust & lock tail stock.	.082	12		.092	
I	" 2-4	Position lathe. tool for facing.	.105	10		.116	
J	" 2-10	Start machine & engage feed.	.051	10		.056	
K	" 2-15	Face off hub side of rim-rough cut PMT=.535'	–	–	–	–	–
L	" 2-21	Feed off-set tool & engage feed.	.187	10		.206	
M	" 2-27	Repeat K for finish cut PMT=.552'	–	–	–	–	–
N	" 2-31	Feed off, set tool for O.D. & engage feed.	.264	10		.290	
O	" 2-33	Take rough cut on O.D. P.M.T.=1.8'	–	–	–	–	–
P	" 3-2	Stop machine-measure & start mach. & feed	.325	13		.367	
Q	" 3-4	Take finish cut 4.125"-4.126" PMT=1.74'	–	–	–	–	–
R	" 3-8	Stop machine & measure.	.286	13		.323	
S	" 3-4	Repeat Q every 7th piece PMT=1.74/7=.25'	–	–	–	–	–
T	" 3-8	Repeat R. every 7th piece.	.286	13	1/7	.046	
U	" 3-10	Remove gear to arbor press.	.215	10		.237	
V	" 3-14	Remove dog & press out arbor.	.237	16			.275
W	" 3-19	Stamp part number on gear & place in tote pan	.518	12			.580
X	" 3-23	Allow 10% attention for K,M,O,Q,&S=4.877X10%	.488	9			.532
Y	" 3-27	Change tool every 25 castings.	.22	12	1/25	.010	

REMARKS

FOREMAN T.S.M. GEN SUPT.

FIG. 15.—A typical machine operation.

On element *K*, the Shop Observation Sheet also contained these data:

$$\begin{aligned} \text{r.p.m.} &= 66 \\ \text{Set feed at CE3} &= .022 \text{ in. feed} \\ \text{Length of cut} &= \tfrac{3}{4} \text{ in.} \\ \text{Stock removed} &= \tfrac{3}{32} \text{ in.} \end{aligned}$$

This element was timed several times and an average of .535 min. P.M.T. was allowed. The calculated time was

$$\frac{\tfrac{3}{4} \text{ in.}}{.022 \times 66} = \frac{.75}{1.452} = .516 \text{ min. P.M.T. or less than 4 per cent difference}$$

Element *M* took slightly longer than *K* because of the draft on the side of the gear blank.

The T.S.M. spoke to the operator about element *N*, because the operator had the habit of stopping his machine and drawing the point of the lathe tool too far away from the work. The lathe was thereafter left running during this element and the tool merely drawn back to the proper location for the next element.

In addition to the legend and timings for element *O*, the T.S.M. listed information for possible future reference:

$$\begin{aligned} \text{r.p.m.} &= 66 \\ \text{Feed} &= .022 \text{ in.} \\ \text{Length of cut} &= 2\tfrac{1}{2} \text{ in.} \\ \text{Rough gear diameter} &= 4\tfrac{3}{8} \text{ in. O.D.} \end{aligned}$$

The average timing was 1.8 min. This was checked by the formula:

$$\frac{2\tfrac{1}{2} \text{ in.}}{.022 \times 66} = \frac{2.5 \text{ in.}}{1.452} = 1.72 \text{ min. P.M.T.}$$

The T.S.M. checked the calculated watch times against the actual watch times selected and found 1.72/1.80 = 95.6 per cent agreement. As the difference was probably due to a belt-slip under the cut, 1.8 min. P.M.T. was allowed.

When element *R* was performed, it was learned that on an average of every seventh piece, the operator had to take an extra cut, because of the .001-in. limit specified for the outside diameter of the gear blank. Element *S* shows one-seventh of

the regular P.M.T. (allowed for element *Q*), and granted to the rework element. The next element in the cycle also had a one-seventh count for which time was allowed.

Element *W* was done by means of a steel stencil stamp which contained the catalogue part number of the gear. The operator used a machinist's hammer to mark the part number on the finished rim face. This work was done internally, as were eight other elements in the cycle.

Because of these Internal elements, the operator had to pay attention to his machine while he was completing the arbor presswork, etc.; therefore, the P.M.T. for elements *K*, *M*, *O*, *Q*, and *S*, as shown in element *X*, were insured by granting a 10 per cent attention time. As previously stated, an attention factor is always Internal and rest must be added to it. In this case, the attention factor was one-tenth of the 4.877 min. P.M.T. or .488 min., but this had to be maintained by a 9 per cent rest allowance, so a final allowed Internal of .532 min. was prescribed. The allowed time for element *X* was not normalized in this case because the normalization of attention factors has not as yet been dealt with. Chapter XII explains the normalizing of attention times.

In element *Y*, because of the fact that the toolroom was instructed to supply sharp lathe tools, the operator had more time to devote to his machine. Instead of walking 250 ft. to and from the grinding stand and sometimes waiting for his turn at the grinding wheel, the spare tool was conditioned for him. Knowing the operator to be an honest fellow, the T.S.M. had him keep a record of the number of castings that could be produced between tool changes. This was found to be a count of 1/25th.

Questions

1. Are P.M.T. elements easier or harder to time than H.M.T.?
2. How are Allowed Externals reduced to an .80 basis?
3. Specify the % N.W.T. formula, based on C. Standards.

Problems

4. What is the F.P.M. of a $5\frac{1}{4}$-in. shaft revolving at 40 r.p.m.? Show formula used to obtain answer.

5. Using the customary machine-shop formula, find out what is the P.M.T. of a lathe element where the work is revolving 140 r.p.m., the feed

used is 2.10 in. per minute, the length of cut is $5\frac{1}{4}$ in., and the T.S.M. has added 4 per cent to the total to take care of belt slippage.

6. What is the sum of the Allowed Externals in Fig. 15 in this chapter? What is the sum of the Internals?

7. In Fig. 15, what is the length of cycle?

8. In Fig. 15, what is the hourly production of gears?

9. In Fig. 15, what is the C. Std. per gear, increased to two places to the right of the decimal point?

10. In Fig. 15, what is the % N.W.T.? Use the recommended formula.

Answers to Questions

1. A P.M.T. element should not be timed until the machine is producing in the official manner. When a machine is operating properly, it is producing at an 80 C. Hour. Therefore, P.M.T. elements are easier to time than H.M.T. elements, since ratings do not accompany watch readings.

2. Allowed Externals are reduced to an 80 basis by multiplying them by the reduction factor, which is .75.

3. $$\%\ \text{N.W.T.} = \frac{\text{C. Std.} \times \text{hourly production}}{80} = \frac{\text{Credors per hour}}{80}$$

Answers to Problems

4. $$\text{F.P.M.} = \frac{D \times 3.1416 \times \text{r.p.m.}}{12} = \frac{5.25\text{ in.} \times 3.1416 \times 40}{12} = 55\ \text{F.P.M.}$$

5. $$\frac{5.25\text{ in.}}{2.1} + 4 \text{ per cent} = 2.6 \text{ min. P.M.T.}$$

6. Sum of Externals = 1.823 min.
Sum of Internals = 2.245 min.

7. Ext. 1.823 min. × .75 R.F. = 1.367 min. Externals @ 80 C. Hour
Sum of P.M.T. elements = 4.877 min.
Length of cycle = 6.244 min.

8. $$\frac{60\text{ min.}}{6.244\text{ min.}} = 9.61 \text{ gears per hour of production}$$

9. Externals = 1.823 min.
Internals = 2.245 min.
4.068 Call 4.1 min. C. Std.

10. 4.1 × 9.61/80 = 49.3 % N.W.T.

NOTE: In order to avoid mistakes, the reader should fix firmly in his mind the proper hourly index figure to be used when computing the anticipated hourly production per manual or machine operation as outlined in Chaps. VIII and IX. These hourly index figures are

Use 80-min. hour for production of manual jobs
Use 80-min. hour for production of H.M.T. jobs
Use 60-min. hour for production of P.M.T. jobs

Chapter X

Types of varying materials that cause fluctuating watch readings despite consistent operator performance will result in doubtful standards unless all work elements involved by the variables are recognized and correctly disposed of. The time values for such variables should not be guessed and perhaps dignified by the name of "selected time," but must be established upon an equitable basis. This is made possible by determining the scope of the fluctuating items and then attaching weighted time values to them.

Figure 16 in Chap. X shows a typical example of incidental elements which should be thoroughly studied. In this illustration, element L calls for a 3 per cent attention factor, but its normalization is not carried out at this point. The normalizing of attention times is not treated until Chap. XII, which takes up the operation of more than one machine.

CHAPTER X

VARIABLES AND INCIDENTALS

Variables are items which are allied with the machine, the equipment, the conditions, or the work and which, by reason of their fluctuating nature, prevent the application of time values that are equitable for any one individually classified item. Since the items vary, it follows that the time values for each must also vary. Therefore, a final time measurement must be set up to recognize the frequency of occurrence of the variables, or for their average.

In the earlier chapters, it was pointed out that watch readings might vary on an even type of work because of the erratic performance of an operator. In that case, the work is within his control and the time values granted are arrived at from proper ratings prescribed for the watch readings. However, variable items are not within the operator's control, so far as evenness of effort is concerned, and the watch readings may be as widely different as the variance of the items themselves. Each variable must be standardized so that its proper normal can be shown on the Shop and Master Observation Sheets.

If the machine or manual effort necessary to take care of a variable is a minor part of the cycle, the disposition of it can be made without prolonged consideration. If the time for handling a variable occupies a major part of the cycle, the Allowed Normal might be compounded from several figurations. Arbitrary selection should not be made of some particular watch reading for an important variable, because this practice will lead to serious errors in many C. Standards.

One common type of variable comes from the material being worked on. The variation may be due to size, contour, or weight that accrues from the raw material, or it may be due to improper completion of a preceding operation. A few illustrations of variables which cause varying watch readings are

Straightening of levers, rods, and shafts.
Balancing of armatures, crank shafts, flywheels, etc.
Trucking of work from various points.
Operation of electric crane from different locations.
True-up work in independent lathe chucks.
Grinding of milling cutters, drills, tools, etc.
Rework, salvage, and repair operations.
Beaming work in cotton mills.
Air-pressure variance in air-operated equipment.
Repairs to steam- and water-testing operations.

In many variable elements there may be certain details that can be classed as constant; this leaves the remaining portion of the elements for more extended analysis.

The T.S.M. will conserve much of his time by following a plan or schedule of time studies to be taken in a department and thereby anticipating the operations that contain pronounced variables. Factory clerks can be compiling information ahead of time, or the foremen can be requested to segregate work into classifications so that they can be studied accordingly for the analysis of variables. Inspection records will yield valuable count data for variables. The first approach to a variable operation is to learn as much as possible about the cause of variance.

In an iron foundry manufacturing floor-type radiators for homes, offices, etc., one of the molding requirements was to cast each radiator section so as to obtain a smooth surface on the outside contours. After assembly, the sections were chipped, filed, and rubbed with abrasive stones to secure the desired finish before painting.

To supply suitable castings, the foundry foreman was constantly supervising sand conditioning, iron pouring and temperatures, cores, chaplets, flasks, flask pins, and many other things that might cause variables to become more pronounced. In spite of his alertness, the surfaces of the radiator sections would vary and cause fluctuating effort on the part of the operators in the machine-shop assembly room.

The T.S.M., in company with the inspector and the machine-shop foreman, inspected several hundred of the various sizes of the assembled sections awaiting the finish operation and decided that all of them represented average commercial foundry practice. Judgment was then passed on the sections by classifying

them into Good, Average, and Bad surfaces. The inspector examined each section and called out one of the three surface conditions applying to it, which was recorded by the T.S.M. When this grading examination was completed for all of the various sizes, the data obtained were as follows:

Size of section	Good	Average	Bad	Total inspected
22 in.	190	285	25	500
26 in.	147	255	23	425
30 in.	220	391	19	630
36 in.	95	180	..	275

The T.S.M. next computed the percentages of the conditions for each size of section by dividing the amount of each size-condition by the total of the particular size in question. This was posted as follows:

Size of section	Good actual	Average actual	Bad actual	Total
22 in.	$190/500 = 38\%$	$285/500 = 57\%$	$25/500 = 5\%$	
	Call 39%	Call 58%	Call 3%	100%
26 in.	$147/425 = 34.6\%$	$255/425 = 60\%$	$23/425 = 5.4\%$	
	Call 36%	Call 60%	Call 4%	100%
30 in.	$220/630 = 35\%$	$391/630 = 62\%$	$19/630 = 3\%$	
	Call 32%	Call 63%	Call 5%	100%
36 in.	$95/275 = 34.5\%$	$180/275 = 65.5\%$		
	Call 28%	Call 66%	Call 6%	100%

To refine the percentages as indicated in the Call rows, it was agreed to have the percentages in the Average column ranging from 58 to 66 per cent, because all sections should be in average condition. Next, the Bad column was considered and, although there were no Bad sections indicated for the 36-in. size, it was agreed to allow 6 per cent for this item. Thus, for the Bad sections, a 3 to 6 per cent range was set up for the sizes as shown. When Average and Bad percentage data had been specified for each size, the differences, subtracted from 100 per cent, were granted to the Call rows for Good castings. The establishment of all these percentage factors not only embraced

the difference in size of product but kept the relation of conditions consistent to each size.

When the T.S.M. had considered sizes and section conditions as variables, he timed and rated several of them. He obtained normals for the classifications and then multiplied each Allowed Normal by the percentage factor. His data for the smallest sized section were

Size of section	Condition	Allowed Normal	Allowed percentage	Normal
22 in.	Good	.75 min. N.	× 39 % =	.293 min. N.
	Average	1.30 min. N.	× 58 % =	.754 min. N.
	Bad	3.20 min. N.	× 3 % =	.096 min. N.
				1.143 min. [call 1.14 min. weighted average N.]

The other sizes of sections were treated in the same manner as the 22-in. size. When all the studies, based on weighted average normals, were completed, the C. Standard for each size was beyond criticism because even they were refined slightly to make them thoroughly consistent with the size of the radiator sections and with the little peculiarities attending certain foundry conditions.

The foregoing method of weighted normals can be used for many various types of jobs, regardless of the industry or kind of product made, and the reader should properly understand this way of handling variables.

Other ways of handling variables are by relative size factors, weights, square or cubic contents, lengths, widths, amount of material removed, etc., where these varying characteristics cause more or less effort to complete the work called for. File strokes, hammer blows, shovelfuls, truckloads, yarn breaks, and dozens of other things can be counted to arrive at the average or weighted average normals. The greater the amounts or volume of the parts under consideration, the more likely it will be that the data are truly representative. Insurance companies do not plot mortality rates from a few hundred persons; their data are taken from the life span of thousands of different classes of people and reconciled with the age status of each person and with the trend of modern times.

Textile mill operations have large numbers of variables. The resolution of them into counts does not require unusual skill; the main thing is to keep an accurate record of each variable item, which should be taken from a volume of parts large enough to be comprehensive. For example, the delicate operation of spinning causes periodical breaks in the roving which is fed into the spinning frame. Whenever a break occurs in the roving, the spinner-tender must walk to the spindle at fault, find and mend the break, and then continue her search for other ends to be "pieced up." This "piecing-up" element is a major part of the spinner-tender's duties; consequently, the correct number of breaks per doff must be determined. Many things influence spinning breaks, such as, condition of the roving, the kind of cotton, the condition of the machine, and, last but not least, the weather. Therefore, in order to secure a comprehensive count of variables, the data should be secured from several days', even weeks', performance. The collection of the data can be handled by a factory clerk or by the operator, thus saving the valuable time of the T.S.M. In the case of the spinning operation, each operator can be given a pencil and instructed to mark on a sheet of paper each break encountered. Later, when the data for all sizes of spinning yarn have been compiled, the number of breaks per size can be refined according to size, *i.e.*, the smallest yarn will have a greater number of breaks than the largest size. Also, the intermediate sizes will have breakage counts that are relative to the sizes specified.

As stated, the T.S.M. must first of all determine if the material being worked on is an average material. If it is not, he should wait until the flow of material is of the average type, unless he is able to interpolate his data to an average basis. A thorough study of inspection or factory office records will generally reflect intelligent variable data. This is particularly true on repair or salvage operations. Since the T.S.M. usually starts his studies on the first operation of a part, he can tell on his subsequent studies of the process whether a previous operation has either induced or aggravated the amount of variables present per operation.

Before incidentals are taken up, one more example of variables will be given which occurred in an automotive-parts plant. Each day several hundred thousand hardened-steel bushings had a hole .625 in. in diameter ground in them to a .0005-in. limit.

The average piecework production on the old basis was 61 bushings per hour per internal grinder. The T.S.M. found a decided variable which covered the stopping of the work spindle, trying a plug gauge in the bushing hole, and then passing the grinding wheel into the bushing again—after which the bushing was regauged. This process, in varying amounts, was repeated on each bushing to obtain the proper-sized hole. It was found that after the grinding wheel had been dressed with the diamond dresser, it required seven to eight grinder strokes to size accurately each bushing hole. When the wheel became dull, it required nine to eleven strokes. The T.S.M. first set up a definite number of bushings to be ground between wheel dressings and then requested the operator to count each stroke of the grinder spindle. On this basis, after dressing the wheel, the operator would feed in his wheel and then count seven strokes, after which the work spindle was stopped and the plug gauge tried in the hole. If the plug did not fully enter, one more grinding stroke would correctly size the hole. On each subsequent bushing, a part of one or more strokes was added to take care of the increasing dullness of the wheel until the total strokes grew to a maximum of eleven, at which time the wheel was again redressed. This simple idea reduced the variable attending this bushing-grinding operation and a new piecework price based on 124 bushings per hour was specified. In this case a careful attention to variables resulted in a production increase of over 100 per cent.

The line of demarcation between a variable and an incidental is sometimes hard to define. In fact, in most cases a variable, when determined, becomes an incidental. An incidental is a count. A count is a fixed number of times that an item of work recurs in each cycle. Several examples of incidentals or counts are

Clean core box every five cores.
Try plug gauge every 10 pieces.
Change tool every 50 pieces.
Adjust machine every 25 castings.
Fix five breaks per doff.
Piece up 1.65 breaks per bobbin.
Oil tap every second piece.
Repair machine jam every 150 yd.
Change milling cutters every 275 castings.
Strip drill from hole twice per cycle.

Dress grinding wheel every nine bushings.
Change bands every 36 hr.
Reream every 3.8 holes.
Move truck containing 950 castings.
File off burr on every 17th piece.
Chip off high sprue on every fifth casting.
Prepare coiled stock every 231 blanks.
Change time card every 150 pieces.

Incidentals are expressed in the Count column on the Master Observation Sheet either as a common or decimal fraction or as a percentage. For example, in "Change drill every five pieces," the count can be expressed as $\frac{1}{5}$, or as 20 per cent.

In automatic screw machine work where parts are made from bar stock, the normal per piece required for stocking the machine with a new bar is found by dividing the number of pieces obtained per bar into the Allowed Normal per bar. For example, assume that screws $\frac{1}{2}$ in. long are made from a brass bar which is 12 ft., 6 in. long. The linear bar inches becomes 12 ft. $\times$ 12 in. + 6 in. = 150 in. long minus $2\frac{1}{2}$-in.-long chucking piece or 147.5 in. net operating length. Further assuming the cutoff tool which severs the finished screws is $\frac{1}{16}$ in. wide, the gross length per screw is $\frac{1}{2}$ in. + $\frac{1}{16}$ in. = $\frac{9}{16}$ in. gross length. The count then becomes

$$\frac{147.5 \text{ in.}}{.5625 \text{ in.}} = 262 \text{ finished screws per bar or } \frac{1}{262} \text{ count}$$

Carrying the same example still further, assume that the operator was allowed .63 min. N. to handle one bar and that to this a 12 per cent rest factor was added. The posting of this example on the Master Observation Sheet becomes

Element	Description	Normal, minutes	Rest, per cent	Count	External, minutes
A	Restock bar in machine	.63	12	$\frac{1}{262}$	.0027

If the reader is farther along in mathematics than the average man, he can use the reciprocal of 262 and multiply by .00382 to obtain the Allowed External. However, a slide-rule figuration for the above becomes very simple:

$$\frac{.63 \text{ min.} \times 1.12}{262} = .0027 \text{ min. N. per screw.}$$

Whenever trucking operations are studied, the amounts of material on the truck can sometimes be measured by a 6-ft. rule, especially flat sheets of material. Measuring the height of the truck load to obtain the count saves a great deal of time. For example, assuming that a truck holds a stack of .025-in.-thick sheet-metal plates and the over-all height of the stack is 61½ in., the number of plates found is

$$\frac{61.5 \text{ in.}}{.025} = 2{,}460 \text{ total plates or } \frac{1}{2{,}460} \text{ count}$$

The fixing of counts is an important step in time study. Some operators are prone to repeat incidentals more often than is necessary because of their fear that piecework prices or standards will be too tight. The T.S.M. might find that one operator will try a gauge on every third piece during the timing of the job and then go back to his regular practice of gauging every tenth piece after the study has been taken. The kind of operation, the type of gauge used, and the tolerances demanded are factors that can be used to specify the correct number of times that a piece of work should be calibrated.

There are occasions when incidentals are not repeated as often as they should be. An instance of this kind occurred in a truck factory on a special machine for boring transmission cases. A 12.5-in. inserted-blade reamer was one of the tools used. Since it required several hours to reset and regrind the reamer blades, it was erroneously believed that, from an economy standpoint, the reamer should be made to last as long as possible between grinds. To this end, the machine had been slowed up to the point where the reamer lasted three weeks before sharpening. When the boring operation was studied, an additional reamer was provided and the machine speed increased to a point where the reamer required a regrinding treatment every three days. This increase of incidentals resulted in a larger daily output of transmission cases.

Another example of changing incidentals occurred in the lathe department of the same truck factory. Several lathes were assigned to the turning of drop-forged shafts at a speed which caused the high-speed steel turning tools to be ground every 50 shafts. Since the turning tools were quite easy to resharpen on a near-by grinding wheel, the T.S.M. speeded up the lathes to a much higher F.P.M. cutting action, with the result that the

lathes cut at the rate of 250 F.P.M., but required sharpening every 10 pieces. The operators sharpened the tools as an Internal element, and since the task of changing tools was a short one, the large increase in output fully justified the change of incidentals from 1/50th to 1/10th.

The T.S.M. may find it well worth while to keep a separate record of certain incidentals with the view to standardizing them later. This standardization may take the form of curves or tabulations for new work encountered or may apply to old operations whenever an official reason causes their restudy.

Figure 16 shows a Master Observation Sheet which covers a milling-machine operation in an office-appliance factory. Only the elements containing incidentals will be commented on.

Element *A* requires the operator to walk to a near-by truck and pick up a box containing 35 cast-iron main frames. Since he does this only every 35 cycles, a count of 1/35th is shown for this Internal element.

Element *C* is necessary because some of the castings have a slight projection on them which prevents the casting from having an even bearing in the milling fixture. To remove the projection prior to operation 7 would have meant an extra operation. Since William Doe has available idle time, he was requested to handle the supplementary filing operation as an Internal element. The count of 20 per cent could have been specified as 1/5th.

By reason of an improperly designed milling fixture, element *J* was necessary to take care of every twelfth casting which would spring or warp out of shape and which therefore called for a rework element. The T.S.M. had anticipated this operation several days before the study was started and requested the foreman to keep a record of all castings requiring element-*J* work. The count of 1/12th was set up.

Elements *K*, *L*, and *M* were likewise necessary for every twelfth casting. Also, elements *D*, *G*, and *H* had to be repeated for each warped casting. The normals for elements *F* and *L* are not correctly specified in the example. The normalization of attention times will be explained in Chap. XII.

The foreman did not at first think it advisable to incur the expense of a new fixture for the apparently small amount of work required for reworking every twelfth casting. However, the T.S.M. showed him that, based on a production of 60,000 casting requirements per year, 5,000 of that number were remilled

THE BLANK CORPORATION
MASTER OBSERVATION SHEET

STUDY No. 278

DEPT. NO. 51 DEPT. NAME MILLING DATE WRITTEN
PART NO. 15720 PART NAME MAIN FRAME
OPERATION MILL BEARING SURFACE FOR END BRACKET OPER. NO 7
MATERIAL CAST IRON, USING PATTERN P15720B
OPERATOR 31-15 WM. DOE ~~FEMALE~~ MALE STARTED 8/3 9 30 STOPPED 8/3 12 00 ELAPSED 2½ HRS.
MACH NO 1253 MACH. NAME NO. 3 BROWN & SHARPE PLAIN MILLER
TOOLS TWO 6" X 1½" X 1½" H.S.S. CUTTERS & ARBOR. FIXTURE NO. 2960. GAGE T570. SPEED 51 RPM 80 F/M FEED .040" PER REV.

CREDOR STD. 1.7 PER CASTING %A.I.T %N W.T. 58.7%

ELEMENT	REFERENCE	DESCRIPTION OF ELEMENTS	NORMAL	REST	COUNT	ALLOWED EXTERNAL	ALLOWED INTERNAL
A	278-1-1	Up box 10ft. away containing 35 Castings	.337	15%	1/35		.011
B	3	Obtain one casting from box.	.054	12	1		.061
C	5	File off rough spot on every 5th CSTG	.200	12	20%		.045
D	9	Clamp work in fixture-up table & feed on	.675	14	1	.770	
E	18	Mill bearing 1½ long x 3/16 deep PMT = .97'	—	—	—	—	—
F	21	Attention allowed for element E = 3% x .97' =	.029	9	1		.032
G	23	Stop machine feed off & return table.	.105	14	1	.120	
H	27	Unload work from fixture & place on gage	.312	12	1	.350	
I	32	Gage each casting to test for warp.	.109	10	1	.120	
J	35	Recut every 12 castings .97 x 1/12 = PMT = .081	—	—	1/12	—	—
K	278-2-3	Handling time for J = D+G+H	1.092	13.5	1/12	.103	
L	6	Attention allowed for element J = 3% x .97'	.029	9	1/12		.003
M	8	Regage for recut work-same as element I	.109	10	1/12		.012
N	12	Away casting to box.	.042	12	1		.047
O	150-6-2	Change cutter every 125 pieces.	3.25	13.6	1/125	.030	
P	—	Change time card every 375 castings.	1.78	9	1/375	.005	
						1.498	
		1.498 + .211 = 1.709 Call 1.70 C. STD.					.211
		EXT. @ 80 = 1.498 X .75 R.F. = 1.124					
		Element E = .97					
		" J = .081					
		2.175 cycle					
		$\frac{60}{2.175}$ = 27.6 castings per hour	$\frac{1.7 \times 27.6}{80}$ = 58.7% N.W.T.				

REMARKS Shop orders = 375 per lot. New fixture to be designed to eliminate the warp. Will cut out elements J, K, L & M.

FOREMAN T.S.M. GEN. SUPT.

FIG. 16.—A machine operation having several incidentals whose frequencies are shown in the Count column.

at an expense of about $185. A new fixture at a cost of $65 was later installed and the C. Std. was revised in accordance with the eliminated elements.

Element *O* called for a cutter change every 125 pieces. This meant changing cutters about twice daily, instead of once daily, before studies were taken. The toolroom ground the cutters and adjusted them to size before sending the extra set to the job. This meant that only 3.25 min. N. per change was required of the operator's time.

The main frames were released in production quantities of 375 castings per lot; consequently the operator had to ring in his time card at the start of each lot of castings, then later ring out his card at the finish. This accounts for the .005-min. Allowed External for element *P*.

Question

1. In what condition should materials be for time study, particularly from the standpoint of setting up variables?

Problems

2. An analysis of a cotton-mill spinning operation showed that an average of 1.78 breaks per bobbin occurred. A normal of .14 min. was set up per break. Also, a 12 per cent rest factor was granted. What is the total Allowed Normal per bobbin? Show answer to three decimal places.

3. Time studies taken in a foundry core room indicated that the element of periodically cleaning certain styles of medium-sized core boxes should occur every 20 cores. The time for properly cleaning one core box (one core per box) was set up as 1.18 min. N. To this was added a rest factor of 11.9 per cent. What is the average Allowed Normal per core box or cycle? Show answer to three decimal places.

4. An operator in a shipping room is assigned to the task of loading motor trucks with three types of boxes. The boxes are classed as Small, Medium, and Large sizes and each motor-truck load always contains the same amount and ratio of box sizes. Each motor truck holds a combination of

Small-sized box	90 total boxes
Medium-sized box	45 total boxes
Large-sized box	30 total boxes

The T.S.M. times and rates the operator on the loading operation and specifies normals and rest factors for the three sizes as follows:

Small-sized box	.12 min. N.	Allow 11 per cent rest factor
Medium-sized box	.16 min. N.	Allow 14 per cent rest factor
Large-sized box	.28 min. N.	Allow 18 per cent rest factor

What is the weighted average normal per box? Show answer to three decimal places.

5. The operation of filing and fitting a part to a machine gun was a pronounced variable. The T.S.M. decided that, if he counted the number of file strokes, he could arrive at a normal per part that would successfully fit the part to the gun selected. Considerable time was spent in timing and rating the operation, in acquiring sufficient data for the proper number of file strokes per fitting, and also in establishing the proper number of fittings per cycle. The one outstanding element in the cycle was element *M* which read, "File three sides to fit chamber." Element *M* was split up to recognize Good, Average, and Bad filing and fitting conditions. It was found from a checkup of all guns assembled during the time-study period that the percentages of variables were

Good type of guns........................	15.0 per cent
Average type of guns....................	80.2
Bad type of guns.........................	4.8
	100.0 per cent

The normal per file stroke for any of the three classifications was .017 min. N., for which a rest factor of 13.8 per cent was allowed. The total file strokes per fitting (not for the cycle) per classification were

Good type requires average of 32 strokes per fitting.
Average type requires average of 59 strokes per fitting.
Bad type requires average of 103 strokes per fitting.

The amount of fitting per classification was set up as follows:

Good type.............................	3.2 fittings per gun
Average type..........................	5.9 fittings per gun
Bad type...............................	8.8 fittings per gun

If the file strokes per fitting, the fittings per classification, and the percentage of classifications are recognized, what is the final Allowed Normal for element *M*? Show normal to three places to the right of the decimal point.

Answer to Question

1. Materials should be in average condition. Credor Standards cover a suitable time allowance for a normal man working at an average rate of speed, on an average type of material, under average conditions and producing an average daily volume of work.

Answer to Problems

2.

	Normal, minutes	Rest, per cent	Count	Allowed normal, minutes
Piece up breaks	.14	12	1.78	.279

(.14 × 1.12 × 1.78 = .279 min.)

3. Since the cleaning occurs every 20 cores, a count of 1/20th is built into the element as follows:

	Normal, minutes	Rest, per cent	Count	Allowed normal, minutes
Clean box every 20 cores	1.18	11.9	$\frac{1}{20}$	.066

4. The first step is to set up a percentage factor according to box size, as follows:

Small-sized...........	90	= $\frac{90}{165}$ =	54.5% of total load
Medium-sized.........	45	= $\frac{45}{165}$ =	27.3% of total load
Large-sized...........	30	= $\frac{30}{165}$ =	18.2% of total load
Total boxes.........	165		100.0% of total load

When the above percentage has been established, the remaining figuration becomes

	Normal, minutes	Rest, per cent	Percentage	Normal, minutes
Small-sized.......................	.12	11	54.5	.073
Medium-sized....................	.16	14	27.3	.050
Large-sized.......................	.28	18	18.2	.060
Weighted average normal minutes per box = .183				

5.

Class	Normal, minutes	Strokes	Rest, per cent	Fittings	Frequency, per cent	Partial normal, minutes
Good...........	.017	32	13.8	3.2	15.0	.297
Average.........	.017	59	13.8	5.9	80.2	5.401
Bad............	.017	103	13.8	8.8	4.8	.842
Final weighted Allowed Normal minutes per part = 6.540						

Chapter XI

Chapter XI answers many of the perplexing questions arising in the disposition of preparation and setup work elements. Table 4 shows the possibilities of standardizing machine oiling. In your industrial standardization of machine-oiling data, you will find that your discussions of them with various plant officials will bring to light many things that will preserve the life of machinery. A case of this kind is cited:

In the grinder department of an automobile plant, the machinery-repair foreman complained about the frequency of repairs which had to be made to one of the main bearings for the grinding-wheel shaft. There were two large adjustable tapered bronze wheel spindle bearings, one of which caused a great amount of trouble.

It was finally learned that the grinder hands did not close the oil cups after oiling the spindle bearings and some of the millions of sparks from the wheel would find their way into one of the open oil cups and soon cause serious damage to the bearing nearest the wheel. When the source of the trouble was discovered, the grinder hands were cautioned not only to keep all oil cups closed, but to wipe carefully the ends of their oilcan spouts to insure the removal of any stray chips that might adhere to the spout ends and thus find their way into the bearings. This attention given to oil cups saved many repair costs.

As setup operations are phases of time-study work which often receive but little attention, this chapter outlines certain principles which should be observed in order to reduce setup costs.

CHAPTER XI

PREPARATION AND SETUPS

Preparation work, in its broadest sense, is the service work performed by the operator before or after a regular setup operation has been made. Often there is but little difference between certain types of preparation work and setup operations, but it seems preferable to classify them separately. Preparation work may be defined as follows:

> *Preparation.*—The auxiliary duties performed by a direct operator on manual or machine-type operations. The duties comprise infrequent items of work which are necessary for the maintenance of the regular or incidental elements in the operations before or after the official setups of the jobs have been completed.

The elements of time covering preparation work are usually built into C. Standards, because they are a small part of, or closely associated with, the regular job. Preparation work has its own C. Standards where the percentage of time involved is too large to be classed as a part of a regular job. No rule can be laid down for this, beyond saying that plant policies or sizes of production lots will dictate the wisdom of incorporating preparation work in C. Standards.

Time studies are taken on preparation work elements in the same manner as for any other elements and the allowed time found is either added to the regular C. Standards or established as a separate time measurement. The elements making up preparation work may be Externals, Internals, or a combination of both. Examples of preparation work are

Fill lubricant tank twice weekly.
Heat soldering irons each morning.
Clean out chips every 2 hr.
Prepare foundry cupola.
Drop cupola bottom after heat.
Reload magazine as needed.
Shovel sand windrows.

Get all productive supplies for job.
Change buffing wheel at end of lot.
Turn on and regulate heat-treatment furnace.
Clean machine at end or start of job.
Oil main spindle every 2 hr.
Oil machine once per day.

A great deal of preparation work can be standardized and placed in data books, tabulations, curves, etc. In fact, one of the best ways for a new man to start time-study work in the capacity of a regular T.S.M. is to ask permission to study preparation and setup work, preliminary to the analysis and study of regular operations. While the new man is doing this valuable incidental work which will dovetail into studies taken at a later date, he is able to make his contact with labor, size up machinery and methods, and otherwise learn of many things that are interfused with time study. Much time will be saved by studying as a group all preparation and setup work. With regard to the foregoing list of preparation items, the last, oiling machines, offers several days of time-study attention.

To obtain time measurements on machine oiling, the first step is to divide the different types of machines into divisions and then list them by size in each division. Against each size should appear information as to the total number of oil cups, oil holes, grease cups, oil reservoirs, etc. After compiling the list of places to be oiled on each machine, the T.S.M. should submit the list to the foreman, the machinery repairman, the boss-millwright, the plant engineer, or others and obtain from them an opinion as to just how often each lubrication point should be serviced by the operators with the best suitable grease or oil. Having obtained this count data, the T.S.M. should be on hand each morning to pick up the timing when the operators begin their preparation work of oiling their machines. If the machines are well guarded with safety appliances, some of the oiling work may be performed as Internal elements and built into the C. Standards as such, thus releasing more of the operators' time for External work.

A summary sheet of machine-oiling data might take the form of the following example in Table 4 on page 197. In that table, the T.S.M. has grouped three sizes of machines used for special purposes. The design of each size was similar to the

TABLE 4.—OILING DATA FOR SPECIAL TYPE W MACHINES

Item	Type of oiling station	Size of cup, ounces	Normal per station, minutes	Amount of stations: Size of machine			Total normal per machine size, minutes					
							No. 1W		No. 2W		No. 3W	
				No. 1W	No. 2W	No. 3W	Ext.	Int.	Ext.	Int.	Ext.	Int.
1	Main bearing, 7:00 A.M.	4	.33	2	2	2	.66		.66		.66	
2	Main bearing, 1:00 P.M	4	.33	2	2	2	.66		.66		.66	
3	Intermediate gear oil hole		.05	1	1	1	.05		.05		.05	
4	Driving gear bearing	3	.25	2	3	4	.50		.75		1.00	
5	Driven gear bearing	3	.25	2	3	3		.50		.75		.75
6	Shifter segment oil hole		.07		1	2				.07		.14
7	Feed-rod bearing	3	.25	2	3	3		.50		.75		.75
8	Main-slide reservoir			1	1	1	.62		.76		.92	
9	Feed-gear reservoir		.28	1	1	2	.28		.28		.56	
10	Main cam reservoir		.45	1	1	1		.45		.45		.45
11	Main cam lever hole A.M.		.06	1	2	2		.06		.12		.12
12	Main cam lever hole P.M.		.06	1	2	2		.06		.12		.12
13	Kneel on floor and open feed box door		.12	1	1		.12		.12			
14	Jack-shaft bearing	3	.25	2	3		.50		.75			
15	Jack-shaft bearing reservoir		.38			1						.38
16	Wipe hands with waste		.17	1	1	1		.17		.17		.17
17	Put away two oil cans			1	1	1		.05		.07		.09
	Total minutes of Externals						3.39		4.03		3.85	
	Total minutes of Internals							1.79		2.50		2.97
	Add on rest factor						12%	12%	13%	13%	14%	14%
	Total minutes allowed Externals						3.80		4.55		4.39	
	Total minutes allowed Internals							2.00		2.83		3.39

other two sizes; the main difference being that the No. 1W size machine was the smallest and the No. 3W the largest. The three sizes were used to machine graduated sizes of the product.

To oil properly each size of machine, a total of 17 elements was required. Some of the stations to be oiled called for service twice daily. The stations consisted of either ordinary oil holes, reservoirs, or 3- or 4-oz. oil cups, and a normal oiling time was set up from time study for each type of station. The number of classified oiling stations per machine size was also shown which, when multiplied by its normal, indicated the allowed External or Internal time element.

After time extensions were made, subtotals of the columns were shown. To these totals, rest factors were granted; the final totals indicated the total daily time in minutes required for oiling each size of machine. The factory operated 8 hr. or 480 min. per day. The T.S.M. converted the total oiling time per machine size into percentage factors. These percentage factors were calculated as follows:

	Externals		Internals	
	Actual, per cent	Allowed, per cent	Actual, per cent	Allowed, per cent
No. 1W	3.80/480 = .792	Call .8	2.00/480 = .417	Call .4
No. 2W	4.55/480 = .948	Call .9	2.83/480 = .59	Call .6
No. 3W	4.39/480 = .915	Call .9	3.39/480 = .706	Call .7

Later, when the productive operations were time-studied, the totals of the Externals and Internals appearing on the Master Observation Sheets were increased by the allowed percentage factors per machine size. For example, the total allowed Externals and Internals for an operation on the No. 3W machine were increased to compensate for machine oiling as follows:

Total Externals 22.6 + .9 per cent = 22.6 × 1.009 = 22.8 min.
Total Internals 25.8 + .7 per cent = 25.8 × 1.007 = 26.0 min.
48.8 min. C. Std.

The T.S.M. selected other types of machines, grouped them, and obtained oiling data from them in the same manner as for

the W-type machines. When all this oiling data had been completed for all makes and sizes of machines, it was filed in data-sheet form and copies of it given to each foreman so that he could occasionally check certain operators to insure thorough daily oiling of the machines.

A question might be raised regarding the logic of spending considerable time collecting such information as oiling data, especially since the resulting percentages found are sometimes quite small and, when added to the figurations of the Master Observation Sheet, effect an almost negligible increase of time per cycle.

The answer to questions of this kind is that modern intensive manufacturing methods demand recognition of all small items of cost. A keen plant manager insists that his purchasing agent must not be content to save pennies in his purchases but must also appreciate the yearly savings accruing from fractions of pennies saved. The same manager demands of his other associates a continual search for and maintenance of all possible economies applying to the best manufacturing practice. Just as shop officials are constantly on the lookout for cost leakages, so should the T.S.M. search for time leakages.

In a previous chapter, it was stated that time study handles in a definite way all items either directly or indirectly related to the operation that is being time-studied. Perhaps one or two insignificant items of minor importance attending some given operation can be disposed of in a casual way without injury to the final time allowance or piecework price, but if the T.S.M. forms casual habits, he will come to grief on important items that require exhaustive deliberation.

One of the grave errors that untrained men in time-study work make is the habit of adding of estimated percentage allowances to watch readings. Meticulous care is exercised by them in painstakingly studying each regular cycle element and perhaps show the time measurements to three or four decimal places. Instead of giving the same degree of care to incidentals, variables, preparation, etc., which must be treated as correlated stories, they blandly add on some percentage, such as 25 to 40 per cent, to cover "Delays and Allowances" and thereby destroy the accuracy that they have employed on part of the time-study work. This practice cannot be called time study. It should rightfully be called time-study *estimates*.

We have previously stated that a T.S.M. must be confined to limits of error in time-study work, just as a mechanic must produce his work within manufacturing tolerances. A mechanic using micrometers might have limits of plus or minus .001 in. for the permissible variance in the size of his work. A T.S.M. must keep the accuracy of his judgment, watch readings, ratings, allowances, and figurations within 5 per cent. This small limit of error does not permit of the practice of shutting one eye, drawing some speculative percentage factor out of thin air, and, without mature thought, adding it to the time measurements that have been found by an entirely different process.

With reference again to the machine-oiling data in Table 4, although the percentages allowed are quite small, the average untrained man assigned to time study might easily allow several times the amount of extra time by adding some arbitrarily selected percentage which may be subject to severe criticism. Nothing can be guessed at in time-study work, unless one possesses that rare virtue of appraisal that errs less than 5 per cent. Therefore, since guesswork cannot be allowed, this obviates the granting of extra time allowances not backed up by facts.

Besides compiling machine-oiling data, the T.S.M. should build up time-study data for many other kinds of preparation work that are peculiar to each industry. The procedure for compiling the information may vary, but the general scheme of first grouping all items into classes and then refining the data by classification holds true in all cases.

Taking up the second part of this chapter, a setup is defined as follows:

> *Setup.*—The initial work of preparing a manual or machine operation for manufacture. It may apply to the beginning or end of a quantity of one or more pieces or lots of work.

Setup work is analyzed and split up into External or Internal elements and studied in the same fashion as regular operations. In departments where there are numerous setup operations, the T.S.M. can group, classify, and study them as he would the preparation work that is outlined in the preceding paragraphs of this chapter.

The line-up of elements for machine setup work covers making a trip to the toolroom or the supply room, securing tool equipment, transporting it to the job, and installing it on the machine. After all machine adjustments have been made, proper feeds and speeds selected, and the operation otherwise "tuned up," a few pieces of work are produced for inspection purposes. If the initial production of pieces is not correct, the setup time interval remains in effect until inspection requirements are satisfied, after which the setup operation terminates.

Where the production is large, many plants use single-purpose machines. On machines of this kind, setups are made when the machines are installed, and the original setups may endure for months before they have to be dismantled. Periodical machine repairs, small adjustments, or tool maintenance, fall into the classification of repairs, incidentals, preparation, etc., rather than that of setup work.

Other plants use general-purpose machines. By reason of their flexibility, these machines handle various kinds of classified operations and, consequently, the question of setups becomes an important time-study issue. Where departments warrant it, one or more regular setup men may be engaged in setting up or dismantling setups on machine and manual operations. These men are more skilled than the average type of operator and usually receive higher hourly rates. Experienced operators often make their own setups and receive credit for them in the form of "day-work time" or by an incentive offered in the form of a piecework price or a fixed time allowance.

The ideal condition in manufacture where numerous setups are encountered is to have extra machines that are being either set up or dismantled by regular setup men or by employees who are paid lower hourly rates. This condition allows regular operators to be kept busy on productive work, thereby eliminating the lost time resulting from the necessity of waiting on setups that are in progress. Of course, extra machines must be considered from the angle of invested capital, depreciation, etc.

At times, it may prove expedient to divide setup work into two divisions on certain jobs. The first division covers the building up of the setup preliminary to starting the regular productive operation, whereas the second division covers the dismantling of the operation upon its completion perhaps several

days later. Having setups split into two divisions often results in savings in costs because the dismantling may be done by the aforementioned lower rated operators.

The T.S.M. may find it desirable to institute more setup operations in a department in order to secure best results. This anomaly occurs on some given operation where the elements of work, although properly specified for the operation, are so fundamentally unlike that too much time is wasted in making machine and tool adjustments to suit each individual piece of work. Consequently, the work is carried through in stages of completion by means of subsetups. For example, a lathe hand is given the job of turning and threading several small, easily handled shafts. After his initial setup has been made, it would not be profitable to change machine adjustments or to change turning and threading tools for each shaft. Instead, the lathe hand will set his lathe and roughing tool and complete the rough turning operation on all of the shafts in the production lot. When this stage is completed, the lathe will be set for the finish turning operation and all shafts will be reworked for this stage. The remaining work of threading the shafts is completed in the third stage. Between these stages, the minor subsetup elements are so negligible that it is highly desirable to specify them as definite elements in the operation. Short subsetup operations should always be incorporated in the cycle of work per operation.

In plants where the work is made in small quantity job lots, the yearly setup costs, if itemized, will prove to be a respectable percentage of the total shop expenses. If the setup times are incorporated in the regular standards, fluctuating unit costs are apt to result, especially if the setup absorption takes place on varying quantities of units per production lot. This fallacy is aggravated when applied to systems that have as their genesis the saving of time spent on each job. It even holds true on the piecework basis, because, although a setup time may be included in a flat money rate per piece of work, nevertheless, a net cost fluctuation will occur per piece after the overhead expense has been applied.

We believe that regular setup operations should not be incorporated in productive C. Standards. Setup operations should have their own individual C. Standards. The reasons for the separation and recognition of setup operations apart from regular

productive operations are many. A few of them will be explained.

First of all, a setup operation, whether performed by a direct or indirect worker cannot be truly classified as a productive operation. We visualize a productive operation as the medium through which actual work is produced. Setup work (although closely related to the medium) prevents actual output until disposed of. It is an accessory to production, but its cost value varies in proportion to productive volume.

Therefore, to prevent direct-unit cost fluctuation, a setup operation should be classed as a *direct excess cost* whether it is performed by direct or indirect labor. If performed by an indirect worker, his time spent on setup work should be classed as direct work and his indirect weekly time credited accordingly.

Poor planning of production schedules will cause excessive setup costs. For example, certain automatic screw machines require about 4 hr. to set up completely. In view of the expense of the setups for this type of machine, it is a shortsighted policy to schedule a small quantity of work per setup. If small quantity lots are unavoidable, then perhaps an automatic screw machine should not be used; a hand-operated type might prove to be more economical. A part of the duties of the T.S.M. is to analyze shop orders to learn if the amount of pieces per shop order justifies the use of machines whose setup or preparation costs are relatively high in comparison to the output required. Specifying production quantities of many kinds of constantly used small machine parts is primarily an engineering problem, because of the necessary preservation of cost balance between setup expense and money values tied up in inventories that are too large.

The sales divisions of factories are often not fully appreciative of the time and expense required to produce hastily requisitioned samples of parts to be sent out on short notice to prospective customers. A sample part thus made often disturbs the productivity of men and machines that are paying satisfactory dividends. The T.S.M. should ascertain if sales policies result in production specifications that minimize setup costs.

Factories manufacturing miscellaneous sizes or types of product are more apt to have setup problems not existing in other factories whose straight-line production and comparatively even

volume do not reflect high excess setup costs. In either type of factory, setup ratios can be established.

The first step is to look over manufacturing records for the purpose of selecting a period of time during which the volume of production, accompanying setup hours, etc., can be specified as representative of average conditions. This reference period will then be used as an index for other manufacturing periods, whether the latter are better or worse. In slack manufacturing seasons, the hours may be greater in ratio to the reference-period hours, in which case all excess hours over the reference-period hours are credited to the department. Many modern industries charge these excess hours, converted to cost values, to their sales departments. Charges thus made are adjusted when the sales volume exceeds the volume indicated by the reference period.

By treating setup operations as direct excess costs, the foremen, plant, or sales officials realize the expense penalties resulting from lack of attention to this important item attending production schedules.

As stated, setup operations should carry their own individual C. Standards. This allows the operator incentives to prepare regular operations in minimum times. In plants where indirect workers work under a premium or bonus plan, there is a financial reward for their completion of setups in the least possible time.

After a setup has been made, the T.S.M. should analyze it thoroughly before he starts his timing. The design of tool equipment will sometimes prolong the time necessary for setting up manual or machine operations. For example, in punch-press departments, it is advisable to use pillar-post die sets. A die set consists of two main parts. The bottom half, or die shoe, contains the die sections, whereas the upper movable half, or punch holder, carries the punch sections. These two halves are kept in alignment by means of two or more vertical steel posts whose lower ends are imbedded in the die shoe. The upper ends of the short shafts engage bushings that are contained in the punch holder. Thus, the punch and die sections are not only in constant alignment which preserves tool life, especially in old presses, but the setting-up time also is expedited. In view of the many punch-press setups that are required per year in a press department, the use of pillar posts on die sets fully justifies the extra initial expense of installing them.

Just as setting-up times on punch and die tool equipment can be shortened by careful attention to design, so time can be saved on jigs, fixtures, etc., by having tool designers give proper consideration to the work involved in periodically installing tool equipment on various manual or machine operations.

The T.S.M. should always give thought to the means by which materials are brought to and removed from operations. One nearly always assumes that materials are conveyed in boxes or barrels. Delicate or fragile parts are insured against damage in handling and transportation by using special work containers. These containers may take the form of flat boards which carry pegs or holes in them to receive each piece of work. Besides preventing injury to each part, these containers enable the exact number of parts per board to be ascertained by a mere glance to see if all pegs or holes in each board are filled. This type of work container, special tray, shelved truck, etc., need not be restricted to delicate parts but can be used for work of a rougher class because it facilitates clerical work counting, inspection, operator efficiency, and many other timesaving items.

No matter what vehicle is used to carry pieces of work, the T.S.M. must see that the work is properly placed at each operation for ease of handling. Therefore, the location of work trucks, barrels, boxes, or other containers must be considered from the standpoint of time and fatigue.

On manual operations of short cycles, setup work should embrace the question of tool equipment location on each operation. Many manual operations can have tools suspended over the job by means of long coiled tension springs or counterweighted wire cables, to the ends of which are attached socket wrenches, electric drills, screw drivers, etc., that are used every few seconds. Instead of picking up a socket wrench from a bench and later laying it down, the operator grasps the tool which is suspended over his work station, pulls it down a few inches to the job, and, after momentarily using it, merely releases his hold on the tool, which returns to its suspended position ready for the next element or piece of work. The preliminary arrangement of tool equipment in this fashion is a part of the setup operation.

After an official setup has been made, the T.S.M. should look it over very carefully before the job is dismissed as "tuned up."

Milling-machine table and grinder stops, shaper and planer strokes, feed stops, etc., which have been positioned by the setup man, should be checked. One instance is recalled in a gasoline engine shop where a multiple-spindle drill press was drilling eight-bolt holes in cylinder heads. The eight $^{15}/_{16}$-in. drills were positioned satisfactorily for radial position, but the setup man inadvertently set one of the drills in its vertical position about ½-in. longer than the other drills in the group. This improper drill setting was the equivalent of drilling through cylinder heads ½ in. thicker than they actually were. The error was caught when the T.S.M. tried to reconcile the actual P.M.T. with calculated machine time.

If plant policies dictate that setup operations should be built into regular productive C. Standards, they can be handled in the same way as the percentage basis for preparation work.

Another way to build setup time measurements into productive C. Standards is by the trial-and-error method. Each regular productive standard is computed in the regular manner and the production per day or more is found from an 80-performance effort. The amount of production thus found per regular C. Standard becomes a count for setup figuration and is handled the same as incidentals figuration. An example of this figuration is as follows:

The total normal setup time, including rest factors for a steam-testing operation, was 28 min. The regular steam-testing operation was then studied and a trial C. Standard of 2.25 min. per casting was secured. The superintendent advised that the setup time be absorbed in one day's output of work. The T.S.M. computed the amount of Credors an 80 operator should produce in the 8-hr. day and then divided this quantity by the trial C. Standard per piece to obtain a day's output.

$$\frac{(80 \text{ C. Hour} \times 8 \text{ hr.}) - 28.0 \text{ min.}}{2.25 \text{ C. Std.}} = \frac{612}{2.25} = 272 \text{ castings per day}$$

It is noted that the T.S.M. assumed the operator would work at an 80 speed, thereby producing 640 Credors per day. From that amount was subtracted the 28-min. setup time allowance, leaving a difference of 612 available Credors for the regular steam-testing operation. The 272 quantity became a count of $^1/_{272}$ and the setup time per piece was computed and added to the regular C. Standard as follows:

$$28 \times \tfrac{1}{272} = .103 \text{ min. partial standard for setup}$$
$$\underline{2.250} \quad \text{trial C. Standard}$$
$$2.353 \text{ min. Call 2.35 min. allowed standard}$$

Thus the original standard of 2.25 min. was increased

$$\frac{2.35 - 2.25}{2.25} = 4.45 \text{ per cent to compensate for setup time.}$$

Of course, if definite quantities per production lot are predetermined, the count for setup figuration can be directly applied without the trial-and-error basis.

Many plants require setup instruction sheets where this class of work is established as separate operations. The Master Observation Sheets and typewritten write-ups of setup operations cover the description of elements, tool equipment, feed and speed data, and all other information which, when presented to the setup man, can be used as a set of instructions to prepare operations in the correct manner for productive performance. This information becomes a set of reference sheets which should be used in checking setups to see that feeds, speeds, or methods are not violated.

If setup work is embodied in productive C. Standards, the setup elements as a group are attached to the end of the regular productive elements on the Master Observation Sheets.

Questions

1. When does preparation work carry its own C. Standards?

2. Should short subsetup operations be included in cycles?

3. Should regular setup operations be included in C. Standards that are established for productive work?

4. Into what classification of costs should regular setup operations be placed?

5. How can excessive setup costs be departmentally controlled by the cost office officials during dull manufacturing periods?

Problems

6. With reference to page 206 and above, how many steam-tested castings per day of 6 working hr. can an 80-Credor operator produce if the final adjusted C. Standard of 2.35 min. is used?

7. In the assembly room of a radio factory, time studies showed that the External element of heating soldering irons each morning required an average of 6 min. It was decided to build this preparation work into the soldering operation. The assembly room operated 8 hr. daily. A C. Standard of

3.2 min. was granted for the regular soldering operation without preparation work. What is the increased C. Standard after the preparation time is absorbed? Show C. Standard to two places to the right of the decimal point.

8. Time-study data showed that 12 per cent External time was necessary for the preparation work on a large machine. Before this percentage was applied, the trial cycle was 46.8 min. long. The power machine time in that cycle was 36.8 min. After the preparation work has been absorbed into the cycle, how many cycles can be obtained in 10 hr.

9. An aluminum foundry-molding operation required setup time to prepare it for productive manufacture. The foundry operated 9 hr. per day. The setup operation was studied and a C. Standard of 36 min. for it was specified. The foundry manager advised that the setup time be absorbed into the regular productive C. Standard on the basis of two 9-hr. days' output by a molder working at 80 effective speed. The time study for the actual molding allowed a trial C. Standard of 3 min. per casting. Using the trial-and-error method to obtain the proper count and the revised C. Standard, compute the production for Saturday's output. The working time on Saturdays is 5 hr. Show the partial setup during figuration to three decimal places. Show the final allowed C. Standard to one place to the right of the decimal point.

10. An 80-performance setup man spends part of his time on direct and indirect work during his 8-hr. day. He must actually spend 15 min. each morning in assisting on supervision duties. This quarter hour cannot be shortened. The rest of the day he spends on regular setup work and on regular production operations. One day he sets up a machine job carrying a 12.8-min. setup C. Standard; one having 2.7 min. setup C. Std.; one having 4.5 min. setup C. Std., and a fourth that carries a 20.0 min. setup C. Std. He completes the four setup jobs at an 80 effective speed and is then assigned to an operation of assembling electric stand lamps which carries 1.16 min. C. Standard per lamp. How many lamps did he assemble on the day in question if he maintained an 80-performance for both setups and productive output of lamps?

Answers to Questions

1. Preparation work has its own C. Standards where the percentage of work involved is too large to be classed as a part of a regular job.

2. Yes. They may occur so frequently during the day that it may be difficult to keep track of them from the standpoint of clerical work.

3. No. Setups may require the attention of higher hourly-rated workers. Cost fluctuations per unit of work are controlled and minimized by the recognition of setup operations as separate items of time. Also, the dismantling of setups can often be handled by employees who receive lower rates than the official setup men.

4. Regular setup operations, whether handled by direct or indirect labor, should be classified as direct excess costs.

5. By establishing setup ratios based on Reference-Period hours. The ratios reconcile the excess setup hours, resulting from lack of productive volume, by charging a possible abnormal percentage of setup hours to cost

accounts, which are beyond the foreman's control. The remaining hours allowed are within the control of the foreman and his disposition of them partly reflects his general ability as a supervisor.

Answers to Problems

6. $\frac{80 \text{ C. Hour} \times 6 \text{ hr.}}{2.35 \text{ C. Std.}} = \frac{480}{2.35} = 204$ steam-tested castings

7. Solving by the normal basis:

$$8 \text{ hr.} \times 60 = 480 \text{ daily min.}$$
$$480 \text{ min.} - 6 \text{ min.} = 474 \text{ min. net productive time}$$
$$\frac{474}{3.2} = 148.1 \text{ daily production @ 60 C. Hour}$$
$$\frac{480}{148.1} = 3.24 \text{ min. C. Std. allowed}$$

Or solving by the 80 basis, the 6 min. must be converted to an 80 basis by dividing by .75, which gives 8 min. allowed.

$$8 \text{ hr.} \times 80 = 640 \text{ Credor min.}$$
$$\frac{640 - 8}{3.2} = 197.5 \text{ daily production @ 80 C. Hour}$$
$$\frac{640}{197.5} = 3.24 \text{ min. C. Std. allowed}$$

8. Trial cycle 46.8 min.
P.M.T. 36.8 min.
External 10.0 × 12 per cent = 1.2 min. preparation External
10.0 min. trial External
36.8 min. power machine time
48.0 min. allowed cycle

$$10 \text{ hr.} = \frac{600 \text{ min.}}{48.0 \text{ min.}} = 12.5 \text{ cycles per 10 hr.}$$

9. The first step is to learn how many Credors an 80 molder can produce in two days' working time; then, from that total, subtract the setup time at 80 effort to arrive at the net Credors remaining for actual molding time. This net time, when divided by the trial Credor Standard of 3 min., indicates the number of cycles per two days' effort, from which the count per casting is secured.

$$\frac{(80 \text{ C. Hour} \times 18 \text{ hr.}) - 36 \text{ min.}}{3 \text{ min. trial standard}} = \frac{1{,}440 - 36 \text{ min.}}{3 \text{ min.}} =$$
$$\frac{1{,}404 \text{ min.}}{3 \text{ min.}} = 468 \text{ trial cycles or } \frac{1}{468} \text{ count}$$

The next step is to build the setup time into the trial C. Std.

$36 \times \frac{1}{468}$ = .077 min. partial standard for setup
3.000 min. trial C. Standard
3.077 min. Call 3.1 min. final allowed standard

The final step is to obtain the production for a 5-hr. working day, as called for by the Saturday working hours.

$$\frac{80 \text{ C. Hour} \times 5 \text{ hr.}}{3.1 \text{ min. C. Std.}} = \frac{400 \text{ Credors}}{3.1 \text{ min.}} = 129 \text{ castings}$$

10. First machine-job setup = 12.8 min. C. Std.
Second machine-job setup = 2.7 min. C. Std.
Third machine-job setup = 4.5 min. C. Std.
Fourth machine-job setup = 20.0 min. C. Std.
40.0 min. setup Credors

8 hr. − ¼ hr. = 7¾ × 80 C. Hour = 620 Credor min.
40 Credor setups
580 Credors available for the lamp-assembly operation

$$\frac{580 \text{ available Credors}}{1.16 \text{ min. C. Std. per lamp}} = 500 \text{ lamps assembled}$$

Chapter XII

Chapter XII takes up the method of establishing time studies on combination machine operations. By use of the A.I.T. (Available Idle Time) principle, several machines can be operated, or fill-in manual jobs assigned, without changing the final time allowances or piecework prices per job regardless of work combinations. The A.I.T. principle recognizes energy expenditure and rewards it in an equitable manner.

Attention factors are necessary for power machine operations, especially where an operator is given more than one machine to run or extra fill-in tasks to absorb his idleness during each cycle. All items of attention are considered as manual energy values and added as extra time allowances to insure quality of output and proper care of machines.

The normalization of attention factors mentioned in previous chapters is explained in this chapter.

When more than one machine is run by the same operator, there may be periods during the day when some or all are momentarily inactive because the operator is busy with other machines in the assignment. These unavoidable machine delays are taken care of by building in interference factors.

CHAPTER XII

AVAILABLE IDLE TIME, ATTENTION, AND INTERFERENCE

Available Idle Time means the leisure period that an operator has after he has attended to all his External and Internal elements in the cycle of a P.M.T. operation. On many types of machines, the P.M.T. may be quite long for after the operator has completed the manual elements in the cycle he has nothing to do until the next cycle. This leisure period of time per operation varies in proportion to the length of the Internals and the P.M.T.

The competition resulting from present-day production methods does not allow an operator much leisure. If he is assigned to a machine whose design permits him spare time, then cost requirements demand that he also operate one or more additional machines. If it is not possible to assign additional like or unlike types of machines, the available idle time of the operator is made use of by specifying manual operations that can be handled in conjunction with the machine operation.

Manufacturing conditions today differ from those of previous years. An illustration is cited of a boring operation in a pump factory. Some of the pumps were very large and the holes in each large pump cylinder required two or three 10-hr. days to finish on special horizontal boring machines. After a pump cylinder had been positioned and clamped on the boring-machine table and the machine feed had been engaged, the operator had from 15 to 25 hr. of almost uninterrupted idle time on each piece of work. Occasionally, he would walk into the hole of the cylinder that was being bored and inspect the cutting action of the boring tool but, aside from this periodical short element of work and tool changes, he enjoyed many hours of leisure. This idle time would be spent in wandering about the factory or in reading books and magazines. Conditions today do not allow this type of idleness. That boring-machine operator, under current intensive methods of production, must run other

machines or absorb manual operations so that he is nearly 100 per cent busy during working hours.

A visit to a modern automobile plant will reveal the fact that operators are kept busy at all times. During the parts of cycles where machines are performing without human assistance, the operators assigned to the machines are given various kinds of fill-in operations so that they do not have any idle time. Therefore, whenever production figures are given concerning the man hours required for building an automobile, it means that each man hour consists of 100 per cent working time. When new models of cars are to be manufactured, labor cost per car is first considered on the basis of total man hours required. The man hours are then translated into terms of employees; each employee is expected to exhibit the suitable amount of energy per hour to meet the predetermined cost figures.

The energy values treated in this book are called Credors. As explained in the foregoing chapters, an average type operator will exhibit 80 Credors per hour if given the proper wage incentive. No matter what type of job in any industry is time-studied, the effectiveness of the effort or energy expended can be measured in terms of Credor-hour performance.

A laborer in the South African diamond mines, when working at a brisk, effectual speed with his pick or shovel, is just as efficient as the brisk-working skilled diamond cutter in New York who shapes the final product into salable gems. It is needless to state that the South African diamond-mine laborer cannot be directly compared to the diamond cutter from the standpoint of skill or muscular effort required for each of the widely different operations. However, in each case, one is as efficient at his task as the other, provided of course each displays the required brisk, effective energy necessary for his task. The brisk, effective speed in each case might, after time measurement, be recorded as 80 C. Hour performances. This same analogy holds true in all other cases of comparison.

The skilled needleworker who works on the finest fabrics displays an effective speed or accomplishment that can be converted to Credor-hour performance. Her 80 C. Hour capacity in terms of skill or output would not be compared to the 80 C. Hour performance of a man unloading pig iron from a railway car, yet the effectiveness of their endeavors is the same in each case.

Daily prepared records that show the average Credor-hour performance per day of each operator in a factory department are useful items of information. The foreman and other plant officials can use the daily information as a guide to manufacturing cost trends. Daily forms (which are summarized at the end of each week) might reflect the performance per day somewhat as follows:

Clock number	Name	Hours in factory	Hours on standard	Credors produced	Credor hour
193	John Jones	8.0	8.0	640	80.0
194	William Smith	7.5	7.2	586	81.4
195	Tom Brown	8.0	5.6	420	75.0
196	Mary White	7.8	7.8	442	56.7
198	Harry Dailey	8.0	8.0	684	85.5
200	May Green	8.0	8.0	495	61.9

The superintendent, in going over this record, does not need to know personally each operator in the list nor be informed of what particular job each was doing. By referring to the list, he knows that John Jones was not late in reporting for work, that he was on standard for 8 hr., that he produced 640 Credors which, when divided by the amount of hours on standard, signalized an average of 80 C. Hour for the whole day.

In the case of William Smith, he was 30 min. late and was only 7.2 hr. on standard. The .3-hr. differential was caused by waiting for work, which could be verified from Smith's shop card. However, the 81.4 C. Hour showed that Smith on the day in question was better than the expected 80 C. Hour.

Operator 196 was not only late but her performance for the day was subnormal. She was a chronic offender as to tardiness and low C. Hours and had been repeatedly warned about her lack of punctuality and poor production records. The superintendent advised one more trial period of two weeks before dismissal.

Operator 198 nearly always showed brilliant performance regardless of the kind of work on which he was placed.

Operator 200 was a comparatively new operator and her Credor Hours increased a little each day.

With reference again to the foregoing list of employee performances for both manual and machine operations, the number of hours on standard should properly be the same as the hours in the factory. The fact that there is a difference in the cases of operators 194 and 195 indicates poor planning on the part of supervision. As stated, William Smith was .3 hr. off standard because of waiting for work. Since he was working on a manual operation, his N.W.T. was 100 per cent. The .3 hr. did not accrue from the operation but from shortsightedness on the part of the foreman.

In Chap. VIII we stated that manual operations occupied the operator's entire time during each cycle, *i.e.*, 100% N.W.T. Since manual operations require constant effort, the only idle time allowed results from breakdowns, waiting for work, or other delays that are beyond the operator's control. Since these delays are beyond his control (and for which he should not be penalized) time-study work recognizes the uncontrollable delays as excess costs. During such delays, an operator is taken off standard and allowed a basic hourly rate until he again resumes work on the same job or on the next job that carries C. Standards. Hence, the modified time postings for Smith.

Tom Brown ran one machine and had a considerable percentage of A.I.T. (Available Idle Time) because his operation cycle was long, because the elements of work were small, and because the foreman did not prescribe extra fill-in jobs. The A.I.T. converted to hours amounted to the difference between 8 and 5.6 hr., or 2.4 hr., which were paid to Brown on a basic hour rate that had been allowed to him for A.I.T. or for various delay allowances. The money value of the 2.4 hr. allowed was in addition to the premium money earned as a result of his 75 C. Hour effort. Had he been given one or more fill-in operations, his hours on standard would have been the same as his hours in the shop, because there were no delay allowances credited to him for the day.

In Chap. IX, it was explained that P.M.T. operations often allow leisure periods to an operator after he has completed the Internal elements. Since his N.W.T. per cycle might not be 100 per cent, his leisure time during the cycle becomes A.I.T. Time study recognizes A.I.T. as another type of excess cost and if the foreman cannot prescribe other additional machines or fill-in jobs to get rid of it, then A.I.T. is credited to the worker

as Time Off Standard. Thus, if an operator works for 8 hr. on a machine operation specifying 72.5% N.W.T., his Time On Standard is 8 hr. $\times$ .725 = 5.8 hr. His A.I.T. therefore becomes 100 per cent $-$ 72.5 per cent = 27.5 per cent $\times$ 8 hr. = 2.2 A.I.T. hr. or Time Off Standard, unless additional time is granted to cover delays, in which case the Time Off Standard hours are increased.

With reference to Fig. 15 on page 172 in Chap. IX, the answer to Ques. 10 stated that the % N.W.T. was 49.3 per cent for the lathe operation on the main driving gear. The difference between 100 per cent and 49.3 per cent, or 50.7 per cent, is the per cent A.I.T. In other words, the lathe hand on this operation would have been idle over one-half of the day unless he had been given a fill-in job to absorb his A.I.T. This procedure protects the energy values that we call Credors.

To emphasize this point, let us assume that two operators are assigned to one lathe each. One man performs the lathe operation as outlined in the preceding paragraph. The second man runs a lathe that is not equipped with power feed; consequently, his work is H.M.T. which keeps him constantly busy throughout the day. Both operators receive the same hourly rate because their work requires the same amount of skill.

The second man must be active continuously, whereas the first one has only 49.3% N.W.T. Present-day manufacturing methods will allow the first operator to make only 49.3 per cent of the premium or piecework money enjoyed by the second man because the energy expended on each of the two jobs is decidedly different. The first man will ask for additional work so that his earnings will be on a par with his harder working companion.

Just as meters register the number of kilowatt-hours of electricity consumed and speedometers indicate automobile speeds, so does Credor-hour performance record the effectiveness of labor. The effectiveness formula for manual or hand machine time operations is

$$\text{Credor Hour} = \frac{\text{C. Std.} \times \text{pieces of work}}{\text{hours on standard}} = \frac{\text{Credors}}{\text{hours on standard}}$$

Example.—An operator in the woodworking department of a chair factory was assigned to the operation of hand finishing chair legs. One day he finished 200 chair legs carrying a C. Std. of 1.8 min. each. He could

not work all day on standard because the foreman requested him to spend $3\frac{1}{2}$ hr. on sample orders for which there were no C. Standards. Based on an 8-hr. working day, what was his Credor-hour performance?

$$\frac{200 \times 1.8 \text{ min.}}{8 \text{ hr.} - 3\frac{1}{2} \text{ hr.}} = \frac{360 \text{ Credors}}{4.5 \text{ hr. on standard}} = 80 \text{ C. Hour}$$

Credit for $3\frac{1}{2}$ hr. of Time Off Standard was also allowed to him based on his "day-work" hourly rate.

The formula for P.M.T. operations, based on less than 100% N.W.T. is as follows:

$$\text{C. Hour} = \frac{\text{C. Std.} \times \text{pieces of work}}{\text{effective hours on standard}} \quad \text{or} \quad \frac{\text{C. Std.} \times \text{pieces}}{\text{effective minutes on standard}} \times 60$$

Example.—A gear-cutting operation carries a C. Standard of 1.75 min. per gear for which 35% N.W.T. is specified. The plant operates 8 hr. per day. An operator is placed on the job and in a total of 8 actual hr. on standard, he produces 124 gears. What is his Credor Hour and how many hours of A.I.T. is he credited with?

$$\frac{124 \text{ gears} \times 1.75 \text{ min.}}{8 \text{ hr.} \times 35\% \text{ N.W.T.}} = \frac{217 \text{ Credors}}{2.8 \text{ hr.}} = 77.5 \text{ C. Hour}$$

8.00 hr. in shop
2.80 effective hr. on standard
5.20 hr. A.I.T. Credit

Example.—The following day the operator was given the same gear-cutting operation but, in addition, was asked to run another gear-cutting machine handling a different kind of gear and carrying a 1 min. C. Std. per gear and 53.8% N.W.T. On this second machine he produced 333 gears in a total time of 8 actual hr. on standard, besides completing the same production on the first machine as on the preceding day. What is his Credor Hour and how many hours of A.I.T. is he credited with?

First machine... 124 gears @ 1.75 min. = 217 Credors
Second machine. 333 gears @ 1.00 min. = 333 Credors
550 total Credors

First machine.... 35.0% N.W.T.
Second machine.. 53.8% N.W.T.
88.8% N.W.T. × 8 hr. = 7.10 hr. on standard

$$\frac{550}{7.1} = 77.5 \text{ C. Hour}$$

8.00 hr. in shop
7.10 hr. on standard
.90 hr. A.I.T.

Carrying the two foregoing examples still further: Assume that the same operator on the third day ran the same two machines and produced the

exact number of gears on each machine as in the second day's performance, but that, in addition to the two machines, he also handled a manual operation. The latter covered the filing of small keys. The C. Standard per key was 1.4 min. He filed 50 keys during the third day, besides operating the two gear-cutting machines. What is his C. Hour?

First machine...	124 gears	@ 1.75 min. =	217 Credors
Second machine.	333 gears	@ 1.00 min. =	333 Credors
Filing of........	50 keys	@ 1.40 min. =	70 Credors
			620 total Credors

First machine...........	35.0% N.W.T.
Second machine.........	53.8% N.W.T.
Manual operation.......	A.I.T.
	100% $\times$ 8 hr. = 8 hr. on standard

$\frac{620}{8} = 77.5$ C. Hour.

Analyzing the 3 days' work, we find that on the first day the operator ran only one machine and, although he earned a 77.5 C. Hour performance, nevertheless, his A.I.T. was such that his effective time on standard amounted to only 2.8 hr. Not only was his total wage less on account of that short actual working time, but the foreman's cost sheet included an item of 5.2 hr. excess time.

On the second day, the operation of the two machines yielded 550 Credors for the basis of the operator's 77.5 C. Hour which made his second day's earnings higher because his effective time on standard was 7.1 hr. Less than 1 hr. was A.I.T.

Adding the manual operation of filing keys to the third day's work absorbed all available idle time, so the operator made more money because his time on standard was based on a full day of 8 effective working hours. No excess costs were charged against the foreman for the third day and although the operator did not quite reach 80 C. Hour output, his performance was considered satisfactory.

If this same operator could not average more than 77.5 Credors per hour for a representative number of days on various kinds of jobs, he would be classed as a 75+ operator. In planning work for him, the foreman would expect 77.5 $\times$ 8 hr. = 620 Credors per day, because that amount is the expected energy value from him in an 8-hr. day.

As stated, A.I.T. should be considered as a direct excess cost. Because of A.I.T., not only are operators restricted from earning

greater wages, but the foremen are charged with the Available Idle Time not made use of. To minimize such penalties, they try to specify 100% N.W.T. to their operators for all hours of the working day.

Often it may be a task to "load" operators whose regular jobs carry A.I.T. The foremen might succeed in finding fill-in jobs for a portion of the day but cannot prescribe them for the full day. Since this condition is not infrequent, the figuration on such occurrence will be given. We shall call the conditions *a* and *b*.

a = Operation with A.I.T. and also a supply of one or more fill-in jobs to be done Internally.
Rule: No A.I.T. is figured or paid.

b = Operation with A.I.T. No fill-in job.
Rule: A.I.T. is required and paid.

Assume condition starts with *a* and ends with *b*, because supply of fill-in jobs runs out. *Procedure:* Time must be recorded when *a* ends and *b* starts. No A.I.T. is figured during *a* but A.I.T. is figured in usual fashion during *b*.

An example of the figuration of conditions *a* and *b* is as follows:

Job 1.—A machine performs an operation which has 1.4 min. C. Std. and 35.0% N.W.T. The supply will last for several days. The production is 160 pieces in 8 hr.

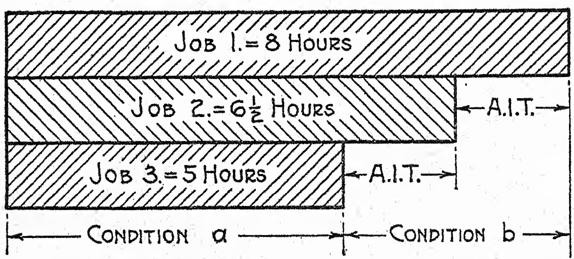

FIG. 17.—Diagram of three different jobs performed in combination by one operator. When two of the jobs are completed during the day the A.I.T. is equitably applied.

Job 2.—The second machine performs another operation which has 2.08 min. C. Std. and 50% N.W.T. The operator exhausts the supply of work for this machine in 6½ hr. He produces 125 pieces during the 6½-hr. period.

Job 3.—The same operator, in addition to handling the first two jobs, also performs a manual operation carrying .50 min. C. Std. per piece. The

supply of manual operation work is exhausted in 5 hr. During that period he produced 120 pieces.

The operator is not entitled to A.I.T. while the supply of fill-in work holds out because his normal working time is 100 per cent for a period of 5 hr. while he is performing the combinations of Jobs 1, 2, and 3. However, after the 5-hr. period, A.I.T. becomes due and payable.

The hours on standard for the three different jobs are shown in Fig. 17.

The figuration for all three jobs becomes:

Job 1.	8 hr.	× 35% N.W.T.	= 2.8 hr. on standard
Job 2.	6½ hr.	× 50% N.W.T.	= 3.25 hr. on standard
Job 3.	5 hr.	× 15% N.W.T.[1]	= .75 hr. on standard
			6.80 effective hr. on standard

Job 1.	160 pieces	× 1.40 min. C. Std.	= 224 Credors
Job 2.	125 pieces	× 2.08 min. C. Std.	= 260 Credors
Job 3.	120 pieces	× .50 min. C. Std.	= 60 Credors
			544 total Credors

$$\frac{544}{6.8} = 80 \text{ C. Hour}$$

8.00 hr. in shop
6.80 hr. on standard
1.20 hr. A.I.T. paid

Whenever indirect workers have spare time, they can be assigned to direct operations during the day. For all Credors that they produce, their hours on standard are credited to their indirect daily records. The formula for this is the same as outlined on page 217 for manual or H.M.T. operations or on page 218 for P.M.T. operations. The use of either formula requires that a record be kept of the Time On Standard so that the credits to indirect hours may be made.

There are times when indirect workers are interrupted so much when they are engaged on direct operations that it is almost impossible to keep an accurate record of their hours on standard. Whenever this condition occurs, the synthetic hours on standard are obtained by formula:

$$\text{Hours on standard} = \frac{\text{Credors produced}}{\text{Department Credor Hour}}$$

[1] This 15% N.W.T. is found by subtracting from 100 per cent the sum of the %N.W.T. factors for the first two operations. Thus only 15 per cent of the time for condition *a* is available for Job 3, since the machines take priority over manual operations in this case.

Before this formula is used, the Credors produced are calculated by a formula used in the cost department at the end of the day. The office formula is

$$d = \frac{c}{h + a}$$

where a = all allowed hours to operators during the day for delays, breakdowns, etc., and for A.I.T.

c = all Credors produced by all the regular direct operators during the day

d = Department C. Hour for the day

h = total effective hours on standard of all direct operators for the day

In order to exemplify the above formula, let us assume that a department contains 12 direct operators. An abstract of the 8-hr.-working-day production records is

Credor performance				Allowance hours		
Clock number	Credors	Hours on standard	Credor Hour	A.I.T. hours	Other hours of delay	Total hours
1	446	6.2	72.0	1.5	.3	1.8
2	559.	6.8	82.2		1.2	1.2
3	640	8.0	80.0			
4	534	7.8	68.5			
5	600	8.0	75.0			
6	234	3.0	78.0	2.7	2.3	5.0
7	400	8.0	50.0			
8	425	5.0	85.0	2.4	.6	3.0
9	674	8.0	84.2			
10	648	8.0	81.0			
11	311	4.0	77.8	3.8	.2	4.0
12	568	7.1	80.0		.5	.5
Total	6,039	79.9		10.4	5.1	15.5

Based on columns 2, 3, and 7, the Department Credor Hour is as follows:

$$\text{Department C. Hour} = \frac{6{,}039}{79.9 + 15.5} = \frac{6{,}039}{95.4} = 63.3$$

The 63.3 Department C. Hour thus found is then applied to the other formula to arrive at the hours on standard for the indirect worker. Let us assume that he worked on various productive operations and, as a result, made 395 Credors for his direct effort. Then:

$$\frac{395}{63.3 \text{ C. Hour}} = 6.24 \text{ hr. on standard}$$

$$\begin{array}{l} 8.00 \text{ hr. in shop} \\ \underline{6.24} \text{ hr. on standard} \\ 1.76 \text{ hr. spent on indirect work} \end{array}$$

Referring again to the performances of the 12 direct operators, their group effort was 6,039 ÷ 79.9 = 75.6 C. Hour, which is all that might be expected as a result of the poor quality of supervision for the day. The foreman could be criticized because he allowed so much A.I.T. and also because he allowed his indirect man to spend too much time on direct work when his services should have been used more in keeping down the excess costs for the day. The indirect workers should work on direct productive work only after they can be of no service to the direct workers.

The elimination of A.I.T. becomes an easier task on the type of work that is repeated over and over again without change and in volume large enough to warrant locating machinery and operations in "straight-line" form. This ideal type of manufacturing program allows the T.S.M., when setting up the correct tool-equipment layout, to confer with production engineers or other plant officials, not only for the proper flow of materials, but also for the assignment of 80 Credors of work per hour to each operator. The reduction of A.I.T. to an almost constant minimum as a result of plant equipment layouts saves many hours of the foreman's planning time.

In plants where products are of a miscellaneous nature and made in small job lots, the foreman is called upon to exercise keen judgment in order to schedule all work so that his men will receive operations or combinations of operations as free as possible from A.I.T. The T.S.M. can greatly assist in this planning work because he has studied all the operations and can suggest combinations of operations whose total percentages of N.W.T. "load" each operator.

The usual way of absorbing A.I.T. is to specify additional machines to the operator. If like machines cannot be prescribed, then unlike machines can be run. If this is not possible, then manual operations can be absorbed. The extra operations selected should at all times be worthy of the operator's skill. For example, a high-priced machine operator should not be kept busy by having to file and chip rough castings brought in from the foundry. This improper grouping of work might not cause the skilled workman to rebel, but the fatigue resulting from the rough job would react against his efficiency on his regular work.

The floor space for machines yielding A.I.T. should be ample enough to allow the installation of extra machines or work benches upon which the operators can get rid of idle time. In a well-known machine-tool factory, there are a number of planer operations, all of which have cycles that allow considerable spare time to the planer men. Their spare time is put to use in manual operations which are performed on benches positioned within a few feet of their machines. The benches contain surface plates, vises, or other fixtures that are suitable for the fill-in jobs handled internally.

After time studies have been taken on machine operations where the % N.W.T. will be less than 100 per cent, the C. Standards should not be built until the question of attention and interference has been solved.

As previously stated in foregoing chapters, attention, with proper rest allowances attached, is always an Internal element. It applies only to P.M.T. operations and relates only to the one or more legends that appear on the Master Observation Sheets and that identify the actual watch readings covering P.M.T. elements. If attention is prescribed from a percentage basis, the time allowance for it must first be normalized and then a suitable rest factor added.

The attention factor for certain machine jobs may consist of a mere glance which the operator occasionally gives to his work. In other cases, attention involves walking or making a rigid inspection of the machine work being done. Consequently, the attention factor for some P.M.T. operations must be more than for others.

The design of a machine or of tool equipment may demand a high attention time. Also, there is the type of machine that handles materials of such high value that unusual time must be allowed to anticipate damages which occur to the work when the operator's attention is divided. This condition must be tempered by the thought that perhaps the operator in his spare time does not give any more attention to his work than he would if he were given additional duties.

When extra machines or manual operations are prescribed for an operator, he should be allowed sufficient time to establish a rhythm of motion before an attempt is made to time study the attention time. If the new assignment of work embraces manual operations in addition to the machine operations, the attention time found applies only to the C. Standards for the machine operations.

In textile mills, the determination of proper attention time for most operations becomes a simple task. The N.W.T. is increased by the granting of more like or unlike machines. To facilitate time-study figuration, the operators who are selected for greater machine assignments should have 80 C. Hour ratings. Thus, the attention time can be normalized more easily than if the operators had a slower effective speed. Having selected an operator for a new line-up of work, the T.S.M., in determining the attention factor, merely time-studies and rates the walking time incidental to attention. The watch is started only when the operator is attention-walking and is stopped at the precise moment when the operator touches the machine to make repairs or adjustments or when he completes the work called for in the regular operational elements. The watch hand is not returned to zero each time; instead, the readings are left to accumulate in intermittent fashion for a period of 1 hr. or longer. If during that time the machines have functioned in their average way, then the accumulated attention time is converted to a percentage basis, normalized, and added to the machine cycles. To illustrate this:

An 80 C. Hour girl operator is given additional machines to run. The new setup requires the tending of five machines. She operates the revised number of machines for several days, after which the T.S.M. studies the attention time for 2 hr. The attention time in this case consists of periodically walking past the five machines and performing work elements when

necessary. The stop watch is in operation during the time that the girl is walking but stopped when the machines engage her efforts. At the end of 2 hr., the accumulated watch readings amount to 12 min. or 10 per cent of the 120 min. observation. Since there were five machines in the group, the percentage is divided by the number of machines; in other words, 2 per cent attention time is specified per machine.

In computing the proper attention time to be added, the 2 per cent is figured from the actual unassisted machine-time length (P.M.T.) of one machine and then normalized. If the actual P.M.T. for one machine was 90.5 min., the figuration becomes

$$\frac{90.5 \times 2 \text{ per cent} \times 80\text{R.}}{60} = \frac{1.81 \times 80}{60} = 2.41 \text{ min. normal attention time}$$

In a previous chapter it was stated that normals can be specified for an operation regardless of the speed that is being demonstrated by an operator under observation. This rule still holds true without exception, but the T.S.M. will find that his figurations become more complex on multiple-machine combinations where the operator being time-studied is slow or erratic in his endeavors. First of all, if the operator is slow, he cannot run the ultimate number of machines that will be considered as the "loaded task." To meet such situations, the slow operator should be given as many additional machines as he can successfully operate, even though the number is less than desired. All his work elements, incidentals, attention, etc., should be studied in the regular manner and the ratings allowed will convert the time measurements to normal times. The normal times when transposed to an 80 basis by means of the reduction factor will indicate the possibilities of the extra machines to be run. Therefore, it is not absolutely necessary to require 80 Credor operators for the multiple work. Whenever they are employed for demonstration, however, fewer errors are likely to be encountered in incorporating the attention and various other time allowances into standards on a direct rather than an interpolated basis.

The T.S.M. may occasionally find that an operator can operate many more machines than the old number, but that quality of work or machine performance might be jeopardized by extending the operator's sphere of action over greater floor space. This kind of problem is sometimes answered by allowing extra help to the operator. The extra help comes from an assistant operator who receives a smaller hourly rate and whose chief duties cover attention, incidentals, and other items of benefit to the regular

operator's expanded work. The assistant, sometimes called a "floater," can perhaps service several groups of operators and keep machines in operation when operators are attending to personal necessities. Many plant officials feel that "floating assistants" are good candidates later on when enlarged production requirements demand more skilled operators.

Foundries, core rooms, heat-treat departments, kilns, boiler rooms, etc., all have pyrometers or other types of instruments which record the action of the unit at work. These units require human assistance and the work involved covers not only basic items of work but also varying attention because of fluctuating unit conditions. After time studies have been taken on the basic items of work in departments of the classifications mentioned, additional C. Standards can be prescribed for the ideal attention in order to keep the instrument recordings within suitable limits of efficiency. Thus, each operator not only receives an incentive for the regular items of work surrounding the fundamental parts of his work but is offered an added incentive for keeping instrument readings confined to the ideal range requested. In addition to the incentives offered, penalties can be attached to time allowances when lack of attention causes improper recordings. The effectiveness of the range of allowable variations can be measured by a device called a "planimeter."

Interference is the third subject to be dealt with at this time. It applies to P.M.T. operations, is always an External, and requires no rest factors. An interference is that portion of time after a machine has completed its cycle when it is awaiting service by the operator.

Interference time is granted to a P.M.T. operation by applying a percentage factor to it in the same manner as for attention. It is applied after attention has been added to the time allowances. In other words, interference is the last item built into a C. Standard. The percentage time is always computed from the trial cycle length. It is only specified for a P.M.T. operation when it is known that additional machines are to be operated by one worker. To make this rule clear, let us assume that the T.S.M. has studied a machine equipped with a power feed and found that the N.W.T. is less than 50 per cent. It is obvious that one or more additional machines can be prescribed. After the extra machines have been allotted, there will be certain

periods of the day when one machine has completed its cycle or awaits service from the operator, who at that particular moment is servicing one of the other machines. The period of time the machine awaits service is interference time; the machine is inactive until the operator again starts it into productive action. The more machines assigned to an operator, the more the interference becomes a paramount issue. This is especially true where unlike machines or machines with different length cycles are assigned as a group to one operator.

Theoretically, if several like machines all having the same length of cycles are allotted to one worker, no interference should be felt, because every morning the operator starts off each machine in progression. It would seem that after he had started each machine in his group in a progressive way, the series of progressions should occur unfailingly in definite intervals. This condition might obtain if every machine ran exactly the same speed as the others, if all tool or supply replacements were exactly alike, and if no delays caused one machine to get "out of step." This Utopian condition is seldom arrived at under today's general conditions where every machine minute is utilized for productive purposes. Of course, where machines and cycles are alike, the interferences will be smaller, but some time during the day or week, unless the operator can anticipate it, there will be a time interval when all the machines in the group are awaiting service. To compensate for this condition, an External interference is added to the cycle length.

If it is known in advance that additional machines cannot be granted to an operator who is running only one machine, then no interference time is necessary. He may be given manual jobs to support his machine work, but it is assumed that the machine is the important part of his duties and that manual operations can be stopped at any time to prevent machine delays. Later on, if one or more machines are added to eliminate A.I.T., the C. Standards covering the machine operations can be changed to include interference.

The percentage of interference per machine is found by time study. The T.S.M. starts his watch at the instant one machine requires service and at the same time rates the movements of the operator pending his arrival at the idle machine. Thus, if the operator is slow, the machine waiting time will be longer

than it should be. This can be adjusted by converting the operator's effective effort to normal and later shortening the machine waiting time by means of the reduction factor. This again suggests the desirability of having 80 operators perform demonstrations on multiple-machine groups as outlined for the figuration of attention.

It is not good manufacturing practice to "load" operators with many machines for the purpose of cutting down A.I.T. when, by so doing, it increases machine interference. No general rule can be given for the maximum amount of total interference time for a group of machines, beyond saying that 10 per cent is rather a high percentage for most types of machines. For example, in order to absorb his idle time an operator might be given four machines to run, each of which required 3 per cent interference factors. The total of 4 × 3 per cent = 12 per cent idle machine time might cut down the machine capacity to such an extent that the purchase of more machines would become necessary to satisfy an erroneous idea of keeping operators 100 per cent busy.

The T.S.M. will often find that operators under an old plan have been assigned to more machines than are advisable from an economy standpoint. He might discover that the quantity of machines require such high percentages of attention and interference factors that good judgment dictates fewer machines and the prescription of fill-in manual operations to absorb the A.I.T. that will result from diminished machine assignments.

After a representative amount of interference percentage factors have been secured from various jobs, the data can be tabulated into suitable form and serve either as reference information or as a direct basis for new time studies. As explained in these pages, it is generally advisable to allot the full complement of machines to an operator and secure interferences from actual timing. However, there will be several jobs requiring time studies which are so similar to the ones previously studied that interference factors can be taken from tabulated records. The data in the records should be refined according to machine classification, kind of work, % N.W.T., length of cycle, etc.

When interference percentage factors are secured from tabulated data, the attention and interference times (in the order named) are added to the total time allowances and the final C. Standards are established; the % N.W.T. is then computed as

outlined in Chap. IX. When this is completed, the number of machines that can be run by an operator is found by dividing 100 per cent by the % N.W.T. per machine. For example, assuming that a power machine time operation specifies 23.8% N.W.T. per machine, how many machines of like make and same work can one operator handle?

Solution:

$$\frac{100 \text{ per cent}}{23.8 \text{ per cent}} = \frac{1.00}{.238} = 4.2 \text{ total machines}$$

With reference to this last example, the assignment would be four machines and on that basis the operator would be 23.8 per cent $\times$ 4 = 95.2 per cent "loaded." If fill-in manual jobs could not be specified, the operator would have 4.8 per cent total A.I.T. or 1.2 per cent per machine. The T.S.M. might feel in this case that the four-machine combination was sufficient and would therefore absorb the small amount of A.I.T. into the C. Standard, thus calling the four-machine basis 100% N.W.T. The revised C. Standard would be obtained by transposing the formula for % N.W.T., as outlined in Chap. IX, to the following:

$$\text{C. Std.} = \frac{\% \text{ N.W.T.} \times 80}{\text{hourly production}}$$

Attaching more values to the foregoing example, assume that the original 23.8% N.W.T. was based on 2.8 min. C. Standard per piece and a production of 6.8 pieces per hour per machine. The revised C. Standard, by use of the transposed formula above, would be solved as follows:

$$\text{C. Std.} = \frac{23.8 \text{ per cent} + 1.2 \text{ per cent} \times 80}{6.8} = \frac{.25 \times 80}{6.8} =$$
$$\frac{20 \text{ Credors}}{6.8} = 2.94 \text{ min.}$$

From the foregoing example, it will be noted that attention and interference can be used as a clearinghouse for C. Standards that are adjusted to compensate for modified percentages of Available Idle Time.

On multiple-machine groups where the combination of machines and work seldom varies and the resulting amount of A.I.T. is so small that it cannot profitably be put to use, it is a

THE BLANK CORPORATION
MASTER OBSERVATION SHEET

STUDY No.

DEPT. NO. DEPT NAME DATE WRITTEN

PART NO PART NAME

OPERATION OPER. NO.

MATERIAL

OPERATOR FEMALE MALE STARTED STOPPED ELAPSED HRS.

MACH. NO. MACH NAME

TOOLS SPEED FEED

CREDOR STD. 2.52' PER PIECE %A.I.T. 55.9% %N W.T. 44.1%

ELEMENT	REFERENCE	DESCRIPTION OF ELEMENTS	NORMAL	REST	COUNT	ALLOWED EXTERNAL	ALLOWED INTERNAL
E		Total of internals A, B, C and D					1.04
F		Take cut across surface 3.25' P.M.T.					
G		Attention = 3% of F = 3.25 X .03 = .0975 @ 80R	.13	10%			.143
M		Total Externals H, I, J, K and L				1.25	
		Allow 2% interference				1.25	
		Total Externals @ 80 = 1.25 X .75 R.F. = .938					
		Element F = P.M.T. = 3.250					
		Trial Cycle 4.188	X 2%	Interf.		.084	
		Add on Actual Interference .084					
		Revised Cycle 4.272					
		Revised Total		Externals		1.334	
		"	"	Internals			1.183
							1.334
							2.517
				Call C. Std.			2.52
		$\frac{60}{4.272}$ = 14. pieces per Hour					
		$\frac{14 \times 2.52}{80}$ = 44.1% N.W.T.					

REMARKS

FOREMAN T.S.N. GEN. SUPT.

Fig. 18.—Application of attention and interference factors to a machine operation.

good policy to absorb the A.I.T. into standards as shown in the last example. This raises the question of the minimum A.I.T. percentage total that should be considered. No set rule can be set up for this because of so many variables. First of all, if the combination of machines and work varies periodically, it is not wise to alter C. Standards in order to satisfy one combination of jobs. It may be true that the resultant A.I.T. costs may be small on one group of work where the operator is almost "loaded," yet, if the combination of work varies at different manufacturing periods, other combinations of A.I.T. present themselves for reconciliation.

A T.S.M. may study and grant heavy attention and interference factors to an operator who is running several machines, but, although the analysis shows that there is enough spare time for the operator to handle more machines, this is objectionable to someone in the management. That plant official might feel that the quality of the product will not permit more machines per man and that the present methods and machine allotment for the particular job should not reflect excess costs in the form of A.I.T. If this feeling cannot be overcome, then A.I.T. can be built into the C. Standards as extra attention time, thus converting idleness into terms of work.

Figure 18 shows the application of a 3 per cent attention factor in element *G* and also a 2 per cent interference factor added to the trial cycle. For the sake of clarity, elements *E* and *M* show totals of Allowed Normals for the Externals and Internals in this particular illustration.

The 3 per cent attention as specified by element *G* was found by time study. As the operator was given an 80 rating for all other elements, the .0975 min. attention therefore had to be normalized to .13 min. and then 10 per cent rest added. The .143 min. Allowed Normal was posted in the Internal Column.

Since the T.S.M. had previously studied another operation similar to Fig. 18, he used a 2 per cent interference factor which was not only granted to the trial cycle but was also added to the column of External work.

The production of 14 pieces per hour was found by dividing a 60-min. hour by the revised cycle.

The % A.I.T. was obtained by subtracting 44.1% N.W.T. from 100 per cent.

Questions

1. Is attention an External or Internal element? On what type of operation is an attention factor prescribed?

2. To what part of time-study figuration is interference time always applied?

3. Are rest factors ever added to an interference time?

Problems

4. An operator is assigned to the operation of three machines. Each machine has a different cycle length and a different percentage of N.W.T. covering the jobs that are being run on the machines. The % N.W.T. for each machine operation is

Machine 1	21.7% N.W.T.
Machine 2	33.7% N.W.T.
Machine 3	9.6% N.W.T.

The factory works 6 hr. per day. How many minutes of A.I.T. will the operator be charged with on the above three-machine combination?

5. An indirect worker finds time during the day to run a H.M.T. operation and produces 260 castings which are covered by a .75-min. C. Std. per casting. As he was not able to keep track of his time, owing to frequent interruptions, credit to his indirect hours was allowed, based on a 78 Department C. Hour. The factory operated 8 hr. per day. What is his total of allowed indirect hours for the day?

6. How many Credors per hour can an 80 operator produce on a machine operation which carries a C. Standard specifying 67.5% N.W.T.?

7. The operation of two machines calls for a total normal working time of 105 per cent. What Credor-hour performance is necessary to take care of the two machines successfully?

8. With reference to Fig. 18 in this chapter, what is the number of machines and fractions thereof that can be operated?

9. Figure 19 shows a semicompleted Master Observation Sheet covering a machine operation. The reader is expected to compute the time allowance for element *G* and post it to the proper column. After this is done, the completed sheet should show figurations for:

a. What is the correct C. Std. per piece?
b. What is the production of pieces per hour on one machine?
c. What is the % N.W.T.?
d. What is the % A.I.T.?
e. How many machines and fractions thereof can be operated?

NOTE: Show answer to 1 place to right of decimal point for *a*.
Show answer to 2 places to right of decimal point for *b*.
Show answer to 1 place to right of decimal point for *c*.
Show answer to 1 place to right of decimal point for *d*.
Show answer to 2 places to right of decimal point for *e*.

THE BLANK CORPORATION

MASTER OBSERVATION SHEET

STUDY No.

DEPT. NO. DEPT. NAME DATE WRITTEN

PART NO. PART NAME

OPERATION OPER. NO.

MATERIAL

OPERATOR FEMALE MALE STARTED STOPPED ELAPSED HRS.

MACH. NO. MACH. NAME

TOOLS SPEED FEED

CREDOR STD. PER PIECE %A.I.T %N.W.T.

ELEMENT	REFERENCE	DESCRIPTION OF ELEMENTS	NORMAL	REST	COUNT	ALLOWED EXTERNAL	ALLOWED INTERNAL
A			.25	12%	1	.28	
B			1.25	14	10%		.143
C			.75	12	1	.84	
D		Machine time 6.5′ P.M.T.	—	—	—	—	—
E			2.50	12.5	1	2.81	
F		Machine time 4.0′ P.M.T.	—	—	—	—	—
G		Attention = 4% of D & F @ 70 R		10	—		
H			.27	9	1		.294
I			1.85	12	1	2.07	
J			.60	15	1		.690
K			1.49	12	1/5		.334
L			1.77	13	1		2.000
M		Allow 2% interference					

REMARKS

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FIG. 19.—Unfinished time study relating to Prob. 9. Use the duplicate for figuration.

THE BLANK CORPORATION
MASTER OBSERVATION SHEET

STUDY No.

DEPT. NO. DEPT. NAME DATE WRITTEN

PART NO. PART NAME

OPERATION OPER. NO.

MATERIAL

OPERATOR FEMALE MALE STARTED STOPPED ELAPSED HRS.

MACH. NO. MACH. NAME

TOOLS SPEED FEED

CREDOR STD. PER PIECE %A.I.T %N.W.T.

ELEMENT	REFERENCE	DESCRIPTION OF ELEMENTS	NORMAL	REST	COUNT	ALLOWED EXTERNAL	ALLOWED INTERNAL
A			.25	12%	1	.28	
B			1.25	14	10%		.143
C			.75	12	1	.84	
D		Machine time 6.5' P.M.T.	—	—	—	—	—
E			2.50	12.5	1	2.81	
F		Machine time 4.0' P.M.T.	—	—	—	—	—
G		Attention = 4% of D & F @ 70R		10	—		
H			.27	9	1		.294
I			1.85	12	1	2.07	
J			.60	15	1		.690
K			1.49	12	1/5		.334
L			1.77	13	1		2.000
M		Allow 2% interference					

REMARKS

FOREMAN T.S.M. GEN. SUPT.

Duplicate FIG. 19.—To be used by the reader for the figuration of Prob. 9.

10. With reference to Fig. 19, if the computed machine assignment is raised to a whole number of machines and a faster operator is able to run them successfully and meet the hourly production per machine, specify the answers to:

a. What is the total number of pieces produced from the total machines in an 8-hr. working day?
b. Based on (*a*), what is the operator's C. Hour?

NOTE: In (*a*) and (*b*) show answers to one place to the right of the decimal point.

Answers to Questions

1. An attention time, plus rest allowance, is always an Internal element and always normalized. It is granted only to P.M.T. operations and only to the actual P.M.T. elements in them.

2. Interference time is always applied to the trial cycle as an External element.

3. No. Interference accrues from a machine's inaction. Rest factors are never granted to a machine's performance.

Answers to Problems

4. The shop operates 6 hr. = 6 hr. × 60 min. = 360 min.

Machine 1	21.7% N.W.T.
Machine 2	33.7% N.W.T.
Machine 3	9.6% N.W.T.
	65.0% N.W.T. × 360 min. = minutes on standard

= 234 min.
A.I.T. = 126 min.

5. $$\frac{260 \text{ castings} \times .75 \text{ min. C. Std.}}{78 \text{ Department C. Hour}} = \frac{195 \text{ Credors}}{78} = 2.5 \text{ hr. on standard}$$

$$8.00 - 2.5 = 5.5 \text{ hr. indirect time}$$

6. 80 × .675 = 54 Credors per hour

7. 105 per cent × 80 C. Hour = 84 C. Hour performance

8. $$\frac{100 \text{ per cent}}{44.1 \text{ per cent}} = \frac{1.00}{.441} = 2.27 \text{ machine operated.}$$

9. Figure 20 on the next page shows the answers as follows:

a. 10.3 min. C. Std. per piece.
b. 3.92 pieces per hour.
c. 50.5% N.W.T.
d. 49.5% A.I.T.
e. 1.98 machines.

10. *a.* 3.92 × 2 machine × 8 hr. = 62.7 pieces per day

b. $$\frac{62.7 \times 10.3 \text{ min.}}{8 \text{ hr.}} = \frac{645.8}{8} = 80.7 \text{ C. Hour}$$

THE BLANK CORPORATION
MASTER OBSERVATION SHEET

STUDY No.

DEPT. NO. DEPT NAME DATE WRITTEN

PART NO PART NAME

OPERATION OPER NO

MATERIAL

OPERATOR FEMALE MALE STARTED STOPPED ELAPSED HRS.

MACH. NO. MACH NAME

TOOLS SPEED FEED

CREDOR STD 10.3 PER PIECE %A.I.T 49.5% %N.W.T. 50.5%

ELEMENT	REFERENCE	DESCRIPTION OF ELEMENTS	NORMAL	REST	COUNT	ALLOWED EXTERNAL	ALLOWED INTERNAL
A			.25	12	1	.28	
B			1.25	14	10%		.143
C			.75	12	1-	.84	
D		Machine time 6.5' P.M.T.	—	—	—	—	
E			2.50	12.5	1	2.81	
F		Machine time 4.0' P.M.T.	—	—	—	—	
G		Attention 4% of D & F @ 70 R	.49	10	—		.539
H			.27	9	1		.294
I			1.85	12	1	2.07	
J			.60	15	1		.690
K			1.49	12	$\frac{1}{5}$		.334
L			1.77	13	1		2.000
M		Allow 2% Interference				6.00	
		Total Externals @ 80 = 6.00 x .75 RF = 4.5					
		Element D - P.M.T. = 6.5					
		" F P.M.T. = 4.0					
		Trial Cycle 15.0	x 2% Interf. =			.30	
		Add on actual Interf. .30				6.30	
		Revised Cycle 15.30					4.00
							6.30
		$\frac{60}{15.3}$ = 3.92 pieces per Hour					10.30
			Cal. C. Std. 10.3				
		$\frac{3.92 \times 10.3}{80}$ = 50.5% N.W.T.					
		$\frac{1}{.505}$ = 1.98 Mach. operated					

REMARKS

FOREMAN T.S.M. GEN. SUPT

FIG. 20.—Completed figuration of Prob. 9.

Chapter XIII

The question of industrial fatigue is one of vital importance. The T.S.M. must consider it as a necessary by-product of manual energy expended and incorporate in his time studies suitable rest allowances for each operator work element in the cycle.

Rest allowances must not be specified in a casual manner, nor in blanket form to the operation as a whole. Instead, individual rest factors per element should be prescribed only after each has been given the same careful analysis that is given to the actual watch readings obtained.

Many times a standard is found wrong not because of faulty timing, rating, or weight of incidentals, etc., but because the rest allowances were not properly valued and applied in consistent fashion to other findings. Chapter XIII emphasizes the need for treating fatigue as carefully as any other allowance specified by the Master Observation Sheet.

CHAPTER XIII

REST FACTORS

The amount of mental or physical fatigue that results from sustained effort on various kinds of work elements is a question that should receive profound study on the part of everyone connected with industry, regardless of its nature.

One of the many things with which time-study work deals is the conservation of human energy. To that end, it eliminates useless motions and thereby releases energy that can be applied to useful motions. Energy values cannot be relied on unless they contain, among other things, proper rest factors that insure their utility.

Fatigue not only diminishes the strength and vitality of labor but reduces the quantity and quality of output. Employers must pay for fatigue because it is a by-product of manual energy. This being true, it is evident that high fatigue ratios attending specific tasks make those tasks cost more than others whose energy values contain lower ratios or percentages of fatigue allowances.

Manufacturers spend thousands of dollars for new types of machines that yield savings worthy of the capital investment. The average plant official, when contemplating the purchase of new machines or laborsaving devices, limits himself to about two broad items of interest. These items concern the preservation or betterment of quality of product and also the question of cost reduction. This latter item may embrace details of savings in the form of time per piece, floor space, horsepower, maintenance, etc., but seldom is the question asked, "How tired will the operator be at the end of the day?" This is a vital question.

Most machine-tool manufacturers lay great stress on their contentions regarding the virtues of their machines, but too little emphasis is given to their statements about the possible low-energy values necessary for successful operation. Time-study men and factory engineers not only should be vitally

interested in the ease of operation of any machines being purchased but should give the same serious thought to any additions or changes to general plant equipment that will conserve human effort.

In Chap. VIII, it was explained that a Credor is made up of part work and part rest, the sum of which always equals unity. In later chapters it was stated that average types of operators should produce 80 Credors per hour. The work or energy part of a Credor is determined after analysis, timing, and rating. Thus, one part of a Credor is obtained by a precise method. The other part, *i.e.*, the rest allowance, may not always lend itself to direct timing and rating; nevertheless, it is subject to analysis. Mature judgment, backed up by compiled data, can often take the place of timing or exhaustive research work in arriving at rest allowances that make up the second part of Credors.

There are so many ramifications connected with the fatigue of some jobs that an untrained man with a stop watch feels that all jobs have intangible fatigue problems so nebulous that he must be granted a special license to guess at the proper percentage of fatigue that accompanies each job. He usually has two or three rest percentage figures in the back of his mind which are applied in blanket form without a second thought to the total time allowances for some given jobs. If his guess is wrong, then the error destroys the accuracy of his watch readings so carefully compiled. If he has prescribed a 25 per cent blanket rest factor when less than 20 per cent is advisable, then his time allowance is loose, the energy values are distorted and 5 or more per cent of cost is dissipated.

It is not our intention to create the thought that this chapter will definitely dispose of any or all fatigue problems that may arise in any industry. We do feel, however, that a trained T.S.M. can approach fatigue problems in a systematic manner and dispose of them in either a direct or indirect way. The direct way solves the problem by actually timing the fatigue that accrues from each job as it is encountered. The indirect way relates to the use of general reference fatigue data prepared after extensive research work on various kinds of jobs. This latter way may in many cases prove to be such a prolonged process that it may not justify the expense involved.

In case time-study schedules do not allow sufficient time to establish rest data by either the direct or indirect ways, a third method, although not as accurate as the others, is close enough for commercial use and is at least consistent for comparative purposes between operations in one plant. The third method refers to setting up rest factors arbitrarily specified for various work elements that are roughly classified for all ordinary types of operational elements in effect throughout the plant. The work elements may be generally classified as follows:

Lift load to bench or machine 1 to 10 lb.
Lift load to bench or machine 11 to 20 lb.
Lift load to bench or machine 21 to 30 lb., etc.

General use of light hammer.
General use of medium hammer.
General use of heavy hammer.

Move table on light machine.
Move table on medium machine.
Move table on heavy machine.

Shovel sand into small flask.
Shovel sand into medium flask.
Shovel sand into large flask.

Move truck empty.
Move truck with light load.
Move truck with medium load.
Move truck with heavy load.

After all general work elements for ordinary jobs to be dealt with in the whole plant have been lined up, percentages of rest factors are applied to each of the classifications. The percentages should fall within a range of 8 to 20 per cent. The classifications that are obviously beyond this range should not be treated as ordinary and the rest factors for them should be found by the stop watch. An example of an ordinary classification would have the percentage range spread over it as follows:

	Per Cent
Move truck empty	8 to 11
Move truck with light load	12 to 14
Move truck with medium load	15 to 17
Move truck with heavy load	18 to 20

It is noted in the above example that the entire range of 8 to 20 per cent is spread over the four divisions, each of which has

its own small range. This latter range provides for the relation which the element bears to the cycle. If moving an empty truck is a comparatively short element of work and therefore is a small part of the cycle, then 8 per cent rest is attached to the normal for that short element on the Master Observation Sheet. Of course, the entire range is not used for every ordinary operation.

The range of 8 to 20 per cent rest factors is predicated on ordinary jobs as follows:

1. The amount of daily working time is 8 hr.
2. The atmosphere is not contaminated with acids, fumes, dust, etc.
3. The working temperatures are between 65 and 70°F.
4. The percentages are based on average types of operators.

With regard to the first item, if the working hours per day are greater or less than 8 hr., the percentage range should be adjusted accordingly. Items 2, 3, and 4 may be passed over at this time since more will be said about them later on.

Rest factors should *never* be applied as a blanket amount to a cycle or total time allowance. Instead, a suitable rest percentage, figured by means of the slide rule, should be added to each individual element in the operation. Although this recommended method often yields C. Standards that will not greatly differ from those obtained by the blanket process, nevertheless, the small differences are well worth while when computed over a year's period of production and converted to money values. If blanket percentage factors are prescribed to over-all time allowances, the T.S.M. will form the habit of using two or three pet figures in his mind that may not be applicable to all cases. This practice will lead to frequent occasions when an angry foreman or operator approaches the T.S.M. with two different jobs in his hands and demands an explanation of a discrepancy in the piecework prices or the time allowances. It may develop that, although both had been accurately timed and rated, the T.S.M., in a misguided moment, had hastily prescribed blanket rest factors so much in error that the harder of the two jobs received a final allowance lower than the easier job. A few instances of this kind will destroy the hard-won confidence that the T.S.M. has built up with regard to fairness and accuracy.

The 8 to 20 per cent range for rest allowance includes a 2½ per cent personal allowance for male operators and a 4 per cent

allowance for female labor. Based on 8-hr. working days, the two basic percentages allow male labor 12 min. and female labor 19.2 min. for drinks of water and for rest-room necessities.

The rest factors granted for many operational elements should be slightly higher for female labor. This is not advisable for all elements, because the proper types of jobs are generally carefully selected for their suitability for female labor.

As stated, the maximum percentage of rest allowance arbitrarily allowed should not exceed 20 per cent. When one stops to realize that 20 per cent of 8 hr. is 1.6 hr. of fatigue allowance per day, it would seem that this amount of time is sufficient to cover the maximum diminishing effort for all ordinary jobs. The jobs that are beyond the realm of ordinary classification should have their fatigue values calculated by means of time measurement.

Fatigue is not a theoretical matter but a subject that represents actual dollars. The T.S.M. must include the subject of fatigue in all his analysis work. When analyzing an operation, he must determine what fatigue is unnecessary and then, if possible, eliminate that fatigue or parts thereof to the point where the remainder falls within the 8 to 20 per cent range.

WORKING CONDITIONS

The work performed may be out in the open or indoors. If indoors, the lighting problem must be taken into consideration. If the work requires close visual attention, the illumination, free from glare or heavy shadows, should be uniformly distributed over the work to prevent eye strain. The operator should not face a strong glare of sun or artificial light, nor should he receive illumination of a flickering nature, as is the case when the light passes through moving parts such as revolving pulley spokes, etc. If eye strain is unavoidable, heavy rest factors must be allowed. Simple devices can often be used to alleviate eye strains. An instance is cited of a girl operator who was constantly engaged on the task of winding white cloth tape about ½ in. wide on large flanged spools. The operation was H.M.T. and her work of properly filling each rapidly revolving spool required a careful visual attention to see that the layers of tape on the spool were correctly overlapped. As the largest percentage of the H.M.T. operation was attention,

a concentrated visual attention was necessary for 85 per cent of the day. This caused a severe eye strain which was aggravated by the fact that the girl faced a white factory wall within 4 ft. of her chair. A small wooden screen painted green was placed immediately back of her work to shut out the white wall from her line of vision. The green surface behind the white tape offered the proper contrast and the headaches suffered by the girl disappeared.

If a department is dirty or the sanitary conditions are bad, this reacts against the morale of the operators and a further fatigue problem becomes an issue.

Also, if there are unusually noisy or vibrating machines or air tools at work, these nerve-racking items affect the vitality of the workers positioned near them.

Sometimes more fatigue is felt by an operator if his work is isolated from other operators. His loneliness directs his thoughts to his own troubles which provokes a mental or physical state resulting in lower energy values. It has often been noticed that the faster workers in a group of men will by their energetic movements increase the speeds of slower workers in the group. Some operators are so susceptible to outside influences that if their work is located near a drinking fountain, they unconsciously slow up whenever one of their shopmates is somewhat deliberate in obtaining a drink of water.

Working conditions that are dangerous and may cause bad injuries induce a mental exhaustion that must be compensated, because a subconscious fear may not be outgrown and, consequently, may prove to be a retarding factor in a man's efforts.

ATMOSPHERE AND TEMPERATURES

The ideal working temperatures for average indoor operations should be from 65 to 70°F. to fall within the 8 to 20 per cent rest factor range. Also, the atmosphere should be reasonably free from injurious ingredients. If the air being breathed by operators is too hot, dry, cold, humid, dusty, full of gas, oil, grease, or acid fumes or other unpleasant smells, then heavier rest factors must be granted. A T.S.M. should promptly make recommendations that cover exhaust fans or other ventilating means by which these vitality-reducing dangers may be overcome and

should point out to shop safety committees the economy of suitable protection against them.

Different seasons of the year often influence the fatigue or productivity of operators. This is especially true in New England textile mills. During the month of August each year, there is a period known as "dog days" when the humidity and temperatures are so high that the sticky weather conditions prevent usual output. This disturbing period of the year reduces the capacity of nearly all operators even though they expend more than their customary effort. This condition is sometimes met by introducing relaxation periods twice a day, at which times all machinery is either stopped or other operators inducted to carry on while the regular operators are regaining energy. In other mills or factories where relaxation periods are not observed, the Credor values are protected by use of a formula similar to that outlined in Chap. XII for indirect workers who are not able to keep accurate records of their time on standards. In their cases, the Department C. Hour is used as an index. In the above case, the Credors produced by each direct operator during the adverse conditions are computed in the regular way and then divided by their own customary Credor-hour performances as exhibited during regular weather conditions. This transposed figuration yields lower hours on standards, which, when subtracted from the true hours on standards, indicates for each direct worker the difference to be charged against the weather or other excess cost accounts.

Some disciples of time-study work feel that low rest factors should be specified for all operational elements and counterbalanced by intelligently distributed relaxation periods which vary in length as manufacturing conditions vary. This practice may be entirely appropriate for many peculiar types of manufacturing, but we feel that for general industry the relaxation periods are usually violated by many of the operators to the point where their energies are further lowered rather than restored. For this reason, we believe that the fixation of suitable rest factors should be based on average weather conditions and should be adjusted when necessary by means of the hours-on-standard medium. There are extenuating circumstances where weather-thermometer readings must be recognized by C. Standards. These will be taken up in the next chapter.

WORKING POSTURES

The postures of operators' arms or other body parts, whether they are working in standing or sitting positions, should receive particular attention on the part of the T.S.M.

The proper height of work, whether the operator is standing or sitting, should be about 2 in. below his elbow height. If the machine or the work is of such dimensions as to prevent this maintenance of height for all of its sections, then the mean section requiring the longest sustained effort as perhaps indicated by the longer time elements becomes the basis for rest allowances. Elements for other sections which impose undue stretching, reaching, stooping, etc., must also be rewarded by heavier rest allowances.

If the work station requires continual standing on concrete or other types of unyielding floors, the operator should stand on a fabric mat or on a soft wooden subplatform to counteract the effects of vitality-reducing floors.

Valuable data have been collected in the past few years by industrial and medical experts that prove the wisdom of having bench, chair, or stool heights carefully specified for the minimizing of fatigue. Their figures prove that production costs in many instances have been materially lowered by using benches and chairs that are not only of proper height but of such design as will further lessen fatigue.

The correct height and general design of a work bench should be determined by the kind of work to be performed on it and also by the average height of the operators to be assigned to the benches. The height of benches should be from 29 to 39 in. as measured from the floor or subfloor to the top surface of the bench. The top surfaces should not be over 3 in. in thickness (less if possible), and there should be no interfering braces or supports that will prevent sitting operators from placing their knees well under each bench. Sitting operators should rest their feet on a footrest which is about 10 in. wide and is installed in a tipped position to the lower part of the bench. The front edge of the footrest should be about 10 or 11 in. from the floor and flush with the front edge of the bench. The back of the inclined footrest should be about 2 in. higher than the front edge. This footrest, if adjustable, can be modified slightly to suit the convenience of different operators.

The stool or chair used for sedentary operations should also receive marked attention. Professional chairmakers who have made investigations of fatigue supply industrial chairs which have wooden, saddle-type seats with suitable back rests. The chairs are adjustable and range from 25 to 31 inches from floor to the top front edge of the chair seat. Where work is made up mostly of pressing attitudes, as when using screw drivers, electric drills, etc., the back edge of the chair seat should be raised enough to compensate for the strain of posture.

Standing or sitting positions are tiresome if either is constantly maintained all day. An operation which requires alternate standing and sitting is the ideal combination of work to keep fatigue at its minimum level. Where this type of combination of standing-sitting postures is not possible, the T.S.M. can often prescribe an incidental element of work in the cycle which requires the operator to walk a short distance to obtain or deliver small quantities of work or to procure tools. This type of incidental element on monotonous or tedious operations offers relaxation in the form of productive work instead of heavier rest allowances.

THE WORKER

As Chap. V outlined the specifications for the proper kind of operator to be placed on each job, none of the characteristics will be repeated beyond saying that before rest allowances are granted, it is assumed that the proper individuals are working on the jobs under analysis. If not, then rest factors are specified for suitable types of operators that ought to be on the jobs. Often the T.S.M. learns, after studying certain operations being performed by men, that the work is suitable for women operators and obtains permission to base different rest factors, if necessary, on the altered operator status before the change is made.

Wearing apparel is sometimes a deterring influence against productive effort. The fatigue caused by the expenditure of energy is a natural consequence and is unpreventable. However, the physical discomfort caused by tight-fitting clothing or improper working shoes is preventable and is therefore not recognized in time-study work. For example, if a girl operator, whose work requires that she stand or walk on hard floors, desires to wear high-heeled pumps in the pursuit of her duties, she should not complain against rest factors that were based on comfortable styles of footwear.

A combination of both mental and physical fatigue retards effective effort more than work elements confined to one of the two classifications. Mental fatigue is hard to measure unless its weight has a direct bearing on quality or volume of work produced, in which event, a reasonable rest allowance can be directly applied. In other cases, mental fatigue must be taken care of by judgment.

During the World War, the manager of a large munition plant which operated three 8-hr. shifts per day received chronic complaints from the operators, foremen, inspectors, and others concerning the working conditions that were left by the preceding shift of men. Each shift of men complained that the tools, work, machines, etc., were always in a bad general condition when they started operations but maintained that, after they had made the necessary corrections, they always left conditions favorable for the next group of men. These series of protests by all three shifts were not lessened by the experimental changes made by the manager. It was his opinion that certain crews of men on one shift held grudges against the men on the next; consequently he altered, without success, the 8-hr. working schedules of each shift to other parts of the 24-hr. day. It was finally learned that all the men and executives were working under such intensive conditions and that the fast tempo of each shift of men induced a mental fatigue so pronounced that they *only thought* they were leaving conditions satisfactory for their successors. This question was adjusted by having overlapping hours for the setup men, inspectors, and toolroom men. Thus, serving the end and also the beginning of two shifts, these key men in their 8-hr. of duty satisfied all the complaints that had previously been made.

THE WORK

Before applying individual rest factors to each element in an operation, the T.S.M. should first consider the operation or cycle as a whole and weigh carefully the relation that one element bears to another in the cycle. An element that is comparatively long and requires laborious effort should have a greater rest allowance if the following element demands the same mental or physical care. Hard elements that are followed by easy ones offer the ideal contrast for fatigue reduction. Each oper-

ation as a whole should be roughly classified as to general type, such as pleasant or disagreeable; slow or nimble; roughing or finishing; light or heavy; ordinary or exceptionally accurate, related or unrelated as to elements, etc.

With reference to the last item, related elements which make up an entire operation are elements of such nature and sequence that the worker can complete one and start the next without awkward pauses, mental or physical adjustments, delays, or slight interruptions. Thus, the continuity of related elements allows the operator to establish a swing or a rhythm of movement that is not only productive but necessitates smaller rest allowances than a series of unrelated elements.

When soldiers are marching to the rhythm of band music, less fatigue is felt than when they are not attention-walking. Laborers who sing or chant during their working movements are not always manifesting a feeling of pleasure in their endeavors but are creating a rhythm for their movements which makes their work easier. A person not conscious of his growing fatigue is less tired at the end of the day than one whose introspection constantly centers upon the likely effects of the work on his efficiency.

Rapidity of motion is not necessarily an energy-consuming medium that must be rewarded by extra allowances. Operations that lend themselves to rapid operation movements are usually made up of short cycles covering light work of such character that repetitive nimbleness is required. This type of nimbleness does not produce the physical exhaustion that is felt from effort applied to operations of long cycles related to heavy work.

Short cycles that include repetitive work of a tedious nature sometimes present an element of monotony that must be recompensed. On monotonous work, the fatigue may be more mental than physical. Since an operation that is monotonous to one worker may be attractive to another, this again may be a question of proper operator selection.

Machine operations usually require slightly higher rest factors than manual operations where the work elements may be directly compared, because the operator not only has the responsibility of his own actions but also must consider the welfare of his machines.

Automatic machines or mechanically paced conveyors may often require muscular effort so strenuous that although the quantity of output is satisfied, the resulting mental or physical reactions cause inferior quality of output.

When rest factors are applied to P.M.T. operations, no consideration is given to the fact that the N.W.T. per cycle may be less than 100 per cent. This refutes an old theory which based rest allowances on the relation of actual manual effort to actual P.M.T. For example, it was felt that if an operator was assigned to a machine whose performance allowed the operator leisure time, the rest allowances should be indirectly proportional to the length of machine times. In Chap. XII, it was pointed out that A.I.T. is an excessive cost to be eliminated. Therefore, an operator is given fill-in work to absorb the idleness that accrues from P.M.T. Being 100 per cent busy throughout the day, he must be given, for each of his operational elements, full rest allowances which will protect Credor values. Of course, the character of fill-in jobs given to an operator may affect his fatigue, but it is always presupposed that since he is carefully selected for his suitability for his main task, the fill-in tasks are likewise selected for their supplementary values.

Chapter IV emphasized the distinct separation of rating and rest factors. Applying a rating to a watch reading only measures the utility of that reading. After the reading has been normalized, its effectiveness is preserved by the application of a proper rest factor, the product of which yields a Credor. This fact is again mentioned, because time studies taken during the latter part of the working day may not always be as accurate as those taken during the earlier hours. This is generally traced to the tired condition of the operator under observation during the final portion of the day. Not only does his accumulated fatigue slow up his actions, but it also causes an erratic demonstration so filled with foreign items that they are hard to recognize and strike out or reconcile by means of judicious ratings. This becomes a harder task if the T.S.M. too is laboring under an accumulated fatigue caused by a hard day's work of unusual mental application. Whenever a T.S.M. feels that the keenness of his judgment is thus becoming dull, he should confine himself to his figurations or other routine work.

Unusual operations that require rest allowances greater than an average of 20 per cent should be timed to obtain the exact or

approximate amount of fatigue involved. To simplify matters, the operator under observation should be in complete sympathy with the work being measured. If the task is being performed in the hot sun, the worker should endeavor to maintain a rhythm of movement all day long, during which time his repetitive work is constantly timed and rated. If it is not possible for the worker to keep up a continuous performance, then his rest periods should be recorded and weighed against the actual periods of work. Thus, if in 8 hr. the total of his rest periods was 132 min., his rest allowance was 37.9 per cent. The demonstration might be repeated on other days by other operators. Also, the time studies might be held open pending tests on other similar kinds of operations in need of unusual rest factors; then, after the determination of these tests, all jobs would be analyzed and a refined scale of percentage factors would be granted for rest allowances for comparable jobs or work elements.

A continuous molding operation in an iron foundry was once studied for several days to learn the effects of the fatigue resulting from the element of pouring the hot iron into the molds. The molder had many other elements to perform, but his sand was dumped into the flasks by means of sand hoppers and his other major work was made so easy that many of his work elements were given 10 per cent rest factors. The actual iron pouring was only a small intermittent part of the recurring daily duties. The iron was delivered to him by an electric crane; after he had poured a group of six flasks, he would prepare six more, etc. The fatigue resulting from the iron pouring was found to be 35 per cent and after this amount was absorbed in the C. Standard for the whole molding operation, the average rest allowance for the job was 17 per cent. Had blanket rest factors been prescribed, it is doubtful if the T.S.M. would have been satisfied with anything less than 25 per cent rest allowance for this molding operation.

Another instance of prolonged studies that were made on an unusual job revealed rest factors that seemed low despite the work being done. The operation consisted of hand-pumping a hot chemical into a series of 50-ft. lead tubes, after which ice was placed on the tubes to chill the chemical suddenly. This operation took place in a low-ceilinged room on a long bench containing a large steam-heated boiling kettle for the chemical at one end and the ice supply at the other. Not only did the operator have contact with extreme heat and cold all day, but

his work of handling the tubes to and from his bench and hand-pumping amid unpleasant fumes called for severe working conditions during his 9-hr. day. This operation was studied for about two weeks and the rest factors granted amounted to a little over an average of 25 per cent. The fact that the operator's monthly performances consistently ran 90 C. Hour indicated that the rest factors were liberal to allow his continued high-energy effectiveness. This operator was an Italian about thirty-five years of age, about 5½ ft. in height, and about 135 lb. in weight.

In previous chapters, it was stated that attention must receive rest allowances. The minimum amount of rest prescribed should be 8 per cent regardless of how simple the element of attention may be. Simple types of attention consist of mere glances periodically given to P.M.T. elements on ordinary operations where the mental or physical requirements are not exacting. In other words, if the rest factors for the elements in an operation are small, the attention allowance can likewise be small. If the attention demands a rigid scrutiny of the work, the percentage must be higher. Attention, whether of the simple or rigid type, should be confined to a range of 8 to 12 per cent rest factors.

In Chap. IV, a constant of .00368 min. per foot was given as the time for an average man to traverse 1 ft. of distance when walking at a normal rate of speed. This constant (no rest included) was obtained from various tests. It was learned that an average person should take between 110 and 135 steps per minute. When walking at less than 110 paces per minute, his length of stride is shortened materially in order to keep his balance. As his number of paces per minute increases, so does his length of stride until he exceeds 135 paces. Then his stride begins to shorten again to the point where it becomes advisable to run instead of walk.

Converting the constant to an 80 basis, or .00276 min. per foot, we see that an average person should walk about 362 F.P.M. or approximately 4.12 miles per hour without rest allowance. The height and weight of various men will cause them to use different numbers and lengths of strides per minute to meet the 80 performance. In support of the .00276 constant, we believe that the ideal combination should be 130.5 steps per minute, each one being 33.3 in. long. This is based on carrying a maximum weight of 5 lb. for clothing, etc. The heavier the weight carried,

the smaller will be the number and length of steps per minute that will be possible.

Since walking induces fatigue, the foregoing data must be insured by suitable rest allowances. The greater the distance walked per day, the larger the allowance that will be necessary. Some studies were made of the fatigue resulting from walking and a curve was plotted from the data found.

Table 5 shows the ordinates of the curve. These ordinates indicate the necessary percentages of rest to be allowed to preserve the .00368 min. constant for normal walking throughout the day, based on different lengths of walking time. For example, a factory clerk must spend 2 hr. per day in actual walking; from Table 5 it is seen that he would require a 16.2 per cent rest factor.

If a work element of attention involves walking, the same table can be used for the rest factors, the minimum being 8 per cent rest allowance.

Problem.—A "loaded" operator, in handling several machines, must give attention to them by periodically walking past each machine and visually inspecting its action. The time study shows that his attention-walking is 15 per cent of his working time of 8 hr. per day. What rest allowance should be added to his element of attention?

Solution:

8 hr. × 15 per cent = 1.2 hr.
1.2 hr. = 11.8 per cent rest (see Table 5)

The foregoing walking data are given to illustrate the possibilities of measuring and standardizing fatigue found from actual time study.

Reference data in the form of tables or curves can be prepared as a guide for rest allowances for many different kinds of work elements, just as tabulated engineering data serve their purpose in industry. The T.S.M. should constantly follow up many jobs that he has previously studied in order to confirm percentage factors of rest allowances. When they have been proved, he should add them to a list of data that later will be refined into a set of constants or curves that are beyond criticism. This reference data will be valuable for new studies and for the guidance of new men hired in the plant for time-study work.

TABLE 5

Walking hours	Rest allowed, per cent	Walking hours	Rest allowed, per cent
.0	2.5	4.2	26.8
.2	4.3	4.4	27.5
.4	6.0	4.6	28.5
.6	7.5	4.8	29.0
.8	9.0	5.0	30.0
1.0	10.5	5.2	30.7
1.2	11.8	5.4	31.2
1.4	13.0	5.6	32.0
1.6	14.0	5.8	32.5
1.8	15.2	6.0	33.0
2.0	16.2	6.2	33.5
2.2	17.2	6.4	34.0
2.4	18.2	6.6	34.4
2.6	19.2	6.8	34.8
2.8	20.0	7.0	35.2
3.0	21.0	7.2	35.5
3.2	22.0	7.4	36.0
3.4	23.0	7.6	36.2
3.6	24.0	7.8	36.7
3.8	25.0	8.0	37.0
4.0	26.0		

Factories that maintain laboratories spend fixed yearly sums to carry on experimental or development work and to protect by tests the quality of their regular product. Exhaustive tests should also be conducted on various types of operations to learn what amount of fatigue per classified work is necessary. In some cases, this may be a matter of science that might go beyond the capacity of time-study men. Nevertheless, since fatigue is an agent that prevents the sustained effort of a given power, it should receive the same thought as is given to any other important principle of manufacturing.

Questions

1. Should blanket rest factors be used in time-study work?
2. If the work elements for each of two operations, manual and machine, are comparable, would the same percentages of rest be granted to each?

3. Should the granting of rest allowances on P.M.T. operations be influenced by the fact that the % N.W.T. for the operation might be less than 100 per cent?

4. What is the recommended range of rest factor percentages for the so-called ordinary types of operations?

5. The recommended range of rest factor percentages established for ordinary types of operations is based on how many hours per day?

Problems

6. In a fishing-rod factory, an operator who makes brass ferules has many various sizes to produce. Some of the sizes are so nearly alike that scarcely any differences in watch readings can be noted. Based on the fact that the larger ferules require more manual effort, it is decided, from the standpoint of costs, to set up rest factors ranging from 12 to 15 per cent for the 11 sizes from 1 to 11 inclusive. This helps to differentiate between the watch readings for some of the sizes. What percentage of rest is applied to each of the 11 sizes? Make a list of the sizes with individually different rest allowances attached.

7. A factory that manufactured a metal article sold 1,500,000 of these articles during the year to the five-and-ten cent store trade at a small margin of profit. The time study for their assembly was correctly taken, but an improper rest factor was granted to element *D*, which read:

Assemble completely: .44 min. N. + 15 per cent = .506 min. Allowed N.

The rest factor should have been 10 per cent instead of the 15 per cent allowed. The assembly operators made 50 cts. an hour on the assembly work. How much money did the factory lose on the year's output because of the incorrectly specified rest factor?

8. An operator, in running a group of machines for 8 hr., has 90.8% N.W.T. His walking time amounts to 10 per cent of his working time. What rest factor should be allowed to him for his daily walking?

9. How many miles per day of 8 hr. can an 80 operator walk if he has a proper rest factor granted to him?

10. In the dye department of a textile mill an 8-hr. operator is required to reach into a tank, pick up a skein of yarn, and wring out the water from it, then walk to a row of hooks and hang the skein on one of them. Before leaving the skein, he must remove all snarls in it. The operational elements for this job are

Element	Description	Normal, minutes	Rest, per cent	Allowed Normal, minutes
A	Pick up skein and wring out.........	.170	12	.190
B	Walk 25 ft. to storage...............	.092		
C	Hang and straighten out snarls in skein...........................	.372	14.5	.426
D	Return 25 ft. to tank...............	.092		

On the basis of the percentage ratio of walking time to the whole cycle, determine by the trial-and-error method the necessary rest allowance for elements *B* and *D*. Use Table 5 for reference. What is the final Allowed C. Standard (shown to 3 decimal places) and how many skeins can an 80 operator handle per day?

NOTE: When computing trial cycles, always include in the figuration every known factor. In this problem, the rest allowances for elements *A* and *C* are known and should, therefore, be built into the trial cycle.

Answers to Questions

1. No. Individual rest factors should be applied to the various work elements making up a cycle or operation.

2. No. The rest factors should be slightly higher for the machine operation to compensate for the operators' added responsibility over their own actions.

3. No. Rest factors are applied to machine operations as though the operator had no leisure time. If his particular machine yields A.I.T., he will be given other machines or fill-in jobs to get rid of it.

4. The recommended rest factor percentage range is 8 to 20 per cent for the so-called ordinary types of operations.

5. The 8 to 20 per cent rest factor range is based on 8 working hr. per day for ordinary types of operations.

Answers to Problems

6. 15 per cent − 12 per cent = 3 per cent to be spread over the 11 sizes in 10 increments, or $\frac{3}{10}$ per cent per size.

Size	Rest, Per Cent
1	12.0
2	12.3
3	12.6
4	12.9
5	13.2
6	13.5
7	13.8
8	14.1
9	14.4
10	14.7
11	15.0

7. The improper rest data were

.44 min. + 15 per cent = .506 min.

The proper rest data should be

.44 min. + 10 per cent = .484 min.

.022 min. error

$$\frac{.022 \times 1{,}500{,}000 \times \$.50}{60} = \$275 \text{ loss}$$

NOTE: The saving in time of .022 min. per piece did not seem much, but, when this has been converted to costs, the yearly loss of \$275 would have paid the tool costs for the whole job.

8. 8 hr. × 90.8 per cent × 10 per cent = .726 hr. Call .8 hr. Table 5 shows 9 per cent rest allowance for .8 hr. walking.

9. $$\frac{8 \times 60}{.00368 \text{ min.} \times .75 \text{ R.F.} \times 1.37 \times 5{,}280} = \frac{480}{20} = 24 \text{ miles per day}$$

10. When the normals for elements B and D are added to the allowed normals for A and C, a trial cycle of .800 min. is obtained:

$$\begin{aligned} A &= .190 \text{ min.} \\ B &= .092 \text{ min.} \\ C &= .426 \text{ min.} \\ D &= .092 \text{ min.} \\ \text{Trial cycle} &= .800 \text{ min.} \end{aligned}$$

$$\frac{B + D}{\text{cycle}} = \frac{.184}{.800} = 23 \text{ per cent of the trial cycle}$$

23 per cent × 8 hrs. = 1.84 hr. Call 1.8 hr.

Table 5 shows 15.2 per cent rest for 1.8 hr. walking.

When this rest allowance for elements B and D has been built in, the revised operational data are as follows:

Element	Normal, minutes	Rest, per cent	Allowed Normal, minutes
A	.170	12.0	.190
B	.092	15.2	.106
C	.372	14.5	.426
D	.092	15.2	.106

C. Std. per skein = .828

$$\frac{80 \text{ C. Hour} \times 8 \text{ hr.}}{.828 \text{ min. C. Std.}} = \frac{640}{.828} = 773 \text{ skeins per day}$$

Chapter XIV

Chapter XIV in its treatment of unusual time studies embraces many of the principles thus far discussed in this book. For illustration, the starching machine operation as shown in Figs. 21 and 22 includes such items as incidentals, preparation, attention, Externals, Internals, variables, constants, changeables, % N.W.T., and A.I.T. due to weather, machine, material, and manufacturing conditions. The fact that these items are all present in one operation should emphasize to you the possibilities of many complex time-study conditions you may meet in the performance of your time-measurement work. Study this chapter carefully, because it contains many of the earlier laws and principles which we have been discussing. Chapter XIV may be said to represent an intensive review of the earlier chapters. If the preceding chapters have been mastered, you will experience but little difficulty with the remainder.

CHAPTER XIV

UNUSUAL TIME STUDIES

The T.S.M. frequently encounters operations so peculiar that they seem to defy time measurement. Others, perhaps, can be successfully timed without a great deal of trouble, but the time measurements cannot be embodied in one C. Standard for each operation. It is the purpose of this chapter to outline a few odd or difficult types of operations and show how they were standardized. It is felt that the few examples selected are comprehensive enough to suggest methods of solution for many other unusual operations requiring standardization.

Separate time studies should always be made for an operation that is completed by two different methods, such as operations on both old and new types of machine. There is no better way of indicating the fallacy of using old machines than by comparison of production costs derived from time studies covering both old and new methods.

Quality factors can be used in conjunction with piecework prices or time allowances that offer an extra reward for the attainment of a quality better than ordinary. Likewise, penalties can be imposed because of failure to meet the degree of quality established before or after time studies were taken. The quality factors are seldom built into C. Standards but are applied when the inspection reports of the work are completed. For example, if a careless operator produced 640 Credors in a day and his work was only 95 per cent satisfactory, he would receive credit for 95 per cent of 640, or 608 Credors. The difference of 32 Credors is the payment the operator made to the company for his carelessness. In this case, the operator is penalized only for his misspent time. Some plant policies impose a C. Standard for bad work that is slightly more than the regular standard. When it is applied to bad work, it levies a penalty that more than covers the time lost by carelessness.

On production lots issued in large quantities to departments, a cost-accounting problem often presents itself if the work is completed by stages. Possibly the operator has spent a whole day on the work, but since none of it is actually finished, no true record of performance can be credited to him. A condition of this kind is sometimes handled by approximating the equivalent pieces of work that have been finished and then allowing credit for the day on that estimate. A much better way is to split up the C. Standard into parts that actually represent the different stages of completion.

Straightening operations for shafts or other metal parts in machine shops offer the more difficult kinds of operations to time-study, particularly if the work has been hardened. The economical way to straighten work is to use hydraulic presses. The following example of how rear axles for automobile trucks were straightened will illustrate one of several ways of solving straightening-operation time studies.

The Job.—Large quantities of nickel-steel shafts about 30 in. long, having several different diameters, ranging from 1¾ to 2½ in. Each shaft has previously been rough-turned and heat-treated to a hard, yet tough condition and now awaits straightening to within .003 in., after which the axles are ground.

The Machine.—Vertical type of hydraulic press with ram operating on the work in its horizontal position. A pressure gauge on the machine shows the various pressures applied.

Tool Equipment.—At the front edge of the machine table, a pair of centers is positioned to receive each shaft. When one shaft is placed in the centers, a sliding dial indicator is moved by hand to each shaft section. The shaft is spun by hand and the amount of runout per section is noted. The shaft is then removed from the centers and placed in V blocks on the machine table; the ram is applied to the sections with the proper pressure for the various degrees of runouts. The shafts are springy and the pressure required for one shaft may not suit another.

Procedure.—The T.S.M. has the foreman and the inspector select 50 shafts that are representative of the straightening conditions to be met. The different sections on each shaft are called *A*, *B*, *C*, *D*, etc. As the operator indicates the runouts for each shaft section, the T.S.M. posts the indicator readings on his Shop Observation Sheet. He times, rates (the ram, when in action, receives an 80 rating), and posts the readings of the pressure-gauge dial for each section. If too much pressure per section is applied, the sections may be thrown in the opposite direction of runout, requiring extra time to bend them back to the desired center line of axis. These improperly performed bendings are later either striken out or adjusted to conform to the general character and liabilities connected with the shafts. Before straight-

ening, some of the shafts may be in the form of a continuous arc, whereas others might be full of kinks caused by the heat-treatment process.

Summary.—The T.S.M. establishes an average amount of runout per shaft section and also the proper pressure to straighten each amount of runout. He also reconciles with his findings the necessary times that the dial gauge must be passed over all sections per shaft in the unsuccessful attempts to straighten each section or to correct those sections displaced when adjacent ones are corrected. The data, when condensed, reflect the pounds of pressure to be applied per .001 in. of runout; the proper number of attempts per section; the necessary amounts of gaugings per shaft and the percentage of variables derived from good, average, or bad shafts per shop order. These constants, when multiplied by the normals per constant and added to the other work elements per cycle, result in the total time allowed per shaft. Since the machine in action operates at an 80, the normal for it is found by multiplying the machine time by 80/60ths or by dividing by .75 conversion factor.

The old length of cycle for the above-mentioned axle before time study was an average of 33.3 min. The C. Standard per axle was set at 6.4 min. per cycle which, when performed at an 80, yielded 12.5 shafts per hour or an increase of 595 per cent in production. The foregoing method can be used for the straightening of other types of materials of various profiles.

As stated before, many operations are of such nature that they cannot be covered by one C. Standard and, consequently, must be taken care of by hyphenated standards or prices. One portion of a hyphenated time allowance represents the basic or constant elements of work connected with the operation, whereas the other, although directly related to the constant elements, is subject to change. The elements in this latter portion are called "changeables." To illustrate these differences, we shall consider a truckload of coal. It will require more time or effort to load and unload the truck if it contains 5 tons of coal than if it contains only 3 tons, yet the delivery time of the coal, for the sake of our illustration, could be the same for either tonnage. The delivery time, *i.e.*, the actual transportation of the coal for a given distance can be classed as a constant, but the work connected with irregular tonnages is a changeable. The solution of this illustration would call for two time allowances: a constant for a part of the job and a changeable, based on pounds or tons, for the other part.

The word "changeable" is used advisedly to prevent confusion with the word variable as outlined in Chap. X. A variable is a fluctuating item that is sometimes indefinite, but a changeable is

one whose value is regulated by definite, although varying, amounts of energy related to constant items.

A typical use of constants and changeables will be given in the following operation covering the assembly of steam radiators for heating dwellings.

The Job.—The assembly operators receive shop orders for sizes or styles of radiators to be made up into units consisting of many or few sections. The constant work covers the installation of tie rods, inlet and outlet connections to end castings, and other general work associated with the finished unit regardless of its total sectional length. The changeable work consists of securing all materials and assembling the amount of sections per unit as requested by each shop order.

Tool Equipment.—Long, low benches containing the tools and small fittings for the work which is assembled on the benches.

Procedure.—Elements are established and classified as constants or changeables. All are timed and rated; then C. Standards are set up after all rest and other allowances have been added. Thus, for example, the data become as follows:

Size of section	C. Standard allowances	
	Unit constant, minutes	Section changeable, minutes
1	2.4	1.2
2	2.8	1.3
3	3.2	1.4
4	3.8	1.6
5, etc.	4.6	1.9

Problem.—How many Credors of effort are necessary to assemble three No. 5 units, each consisting of 10 sections?

Solution:

$$\begin{array}{lrl} \text{3 No. 5 units} = & 3 \times 4.6 = & 13.8 \text{ constant Credors} \\ \text{30 sections} & = 30 \times 1.9 = & \underline{57.0} \text{ changeable Credors} \\ & & 70.8 \text{ total Credors} \end{array}$$

Credor Standards represent the amount of energy to be expended for the completion of a task. If two operations are almost alike with the possible exception of some small details, the energy value, hence the cost values, can be protected by the specification of the same C. Standards for each operation up to

the point where they require common effort. Beyond that point, the supplementary standards measure the values of the small differentiating details. Thus, the hyphenated standards for the assembly of a machine part might be listed as follows:

Operation	C. Standard allowances		
	Constant, minutes	Changeable, minutes	Total, minutes
Assemble domestic model............	27.3	3.2	30.5
Assemble foreign model.............	27.3	5.3	32.6

As stated in the previous chapter, weather conditions often influence the values of the time allowances that have been granted. Since a Credor reflects the energy required, it becomes ambiguous unless it meets varying manufacturing conditions. A case of this, for example, is the opening of asphalt barrels.

The Job.—Wooden barrels containing asphalt are opened by the manual operation of chopping away the hoops and barrel staves with an ax, after which the barrel pieces are carted away. The asphalt remains in the form of a solid mass conforming to the shape of the barrel which contained it. The asphalt is rolled onto platform scales and weighed. This work is constant regardless of weather conditions.

Changeables.—The asphalt, after being weighed, is placed in a hand fixture which draws a small wire through its largest diameter and then through its lengthwise section. Thus the asphalt is first cut into quarters. Afterward, the operator, using his hand ax, breaks up the quarters into lumps about the size of baseballs. This is necessary to allow the lumps to enter the small openings of tanks placed on machines elsewhere at work in the plant. If the weather is cold, the ax will break each piece of asphalt as effectively as though the ax had penetrated dry wood. If the weather is hot, the asphalt becomes a resisting mass that can be broken up only by repeated blows with an ax that is occasionally chilled in ice water. Therefore, whenever the weather is cold, the work of preparing asphalt is a great deal easier than in hot weather.

Procedure.—Ten barrels of asphalt of average weight were selected for the test. Five of them were placed in an icehouse for several days and the other five were left for a few days in an oven maintained at a temperature of 95°F. These hot and cold conditions represented the extreme local weather conditions to be met. Each of the two groups of five barrels was then timed and rated, ax blows were counted, asphalt pieces obtained, etc., and C. Standards set up for the two extreme weather conditions. From these data a

curve was made which embraced both the constant and changeable time allowances. The ordinates of the curve indicated the proper C. Standard per pound to be used in accordance with the particular weather temperatures existing. By reason of this setup, the operator was allowed a great deal more time to handle asphalt barrels on hot days than on cold ones. Whenever barrels were opened, the average temperature for 3 days was allowed to compensate for weather penetration to the center of each asphalt barrel.

The foregoing example pertained to work of a changeable nature that reflected varying effort on account of weather conditions. Another example will be given covering the handling of widely varying fatigue resulting from weather conditions.

The Job.—Operators using tongs are required to reach into furnaces, withdraw vessels containing molten glass, and pour the contents into molds, the cavities of which produce small glass disks.

The Equipment.—As glass is melted at high degrees of heat, the furnaces are operating at white-heat temperatures. The heat is so terrific that the operators cannot stand directly in front of the furnaces without some protection. This partial protection is offered by a sheet of plate glass suspended a few feet from the furnace door opening which baffles some of the heat. Each operator wears asbestos gloves with long cuffs that extend well up on his arms.

The Operation.—From his position in front of the furnace, the operator reaches around the plate-glass screen, withdraws a vessel from the furnace by means of his tongs, then retreats a few steps and pours the molten glass into the mold cavities. This constant type cycle is repeated as often as he can stand it. The work is so exhausting that even in cold weather the operators must have rest periods at frequent intervals. If the weather temperatures and humidities are high, the rest periods must be more frequent and of longer duration.

Procedure.—The job was studied under various weather conditions. On account of the nature of the work, the operators, while at their furnace stations, performed all items of work at a fast speed; consequently, high ratings were given to them. The main part of the time-study analysis was the timing of the length and frequency of the operators' rest periods. To secure proper rest and to recover from the intense heat, they would periodically walk out into the outdoor atmosphere and fill their lungs with air, regardless of prevailing weather conditions. On hot days when the humidity was high, the rest periods would, of course, be much longer. After prolonged observations that ran intermittently for months on the different operators, graduated rest factors were set up as changeables, which, when added to the constant time allowances per pound of glass, resulted in time values suitable for a range of weather conditions from favorable to adverse.

Checking Cards.—At the end of the day, each operator's production ticket or checking card specified the total poundage of glass that he had poured and the mean weather temperature that had prevailed for that day. The cost department then multiplied his total daily poundage not only by the

constant C. Standard but also by the suitable changeable C. Standard which had been determined from the weather fatigue curve.

Although the foregoing examples call for analysis and figuration that are different from the ordinary run of jobs, nevertheless their solutions are comparatively simple. One more example will be given which not only embodies constants, changeables, and varying weather conditions but also compensates for a changeable % N.W.T. resulting from varying combinations of changeables.

The Job.—A large roll of thin cloth 40 in. wide must be passed through a bath of hot starch, dried, and rerolled into smaller rolls.

The Machine.—A simple type of belt-driven machine equipped with a variable speed transmission unit so that speeds are regulated to suit weather and operating conditions. The over-all length of the machine is about 35 ft. Its front end contains a pair of centers called a creel which receives one large roll of cloth. At the other end is a similar pair of centers which receive the cloth in a roll after it has passed through the machine. Between the machine ends are a hot starch bath, wiper rolls, revolving steam drums and finally a series of horizontal steam pipes. The cloth must pass through the bath and over the drums and steam pipes before its delivery in a perfectly dry state at the rear end of the machine.

The Material.—The cloth is received in the form of large supply rolls called bales. Each bale is 40 in. wide and contains a total yardage ranging from 2,800 to 3,200 yd. Since the textile mill cannot supply this yardage in one single strip, each bale is made up of many sewed-together lengths called "cuts." Each cut is indicated by a narrow strip of red cloth placed on the cut by the textile mill. This red flag extends out from the edge of the bale so that the starch-machine operator can anticipate each cut as it approaches his machine. There are from five to nine red flags in every bale, so the bales vary in both cuts and yardage. The delivery roll must be 1,500 yd. long or about one-half a creel bale.

Method of Analysis.—By reason of the changeables encountered because of weather and bale contents, the operator's effort must be paid for in accordance with his varying work per yard. This condition is taken care of by hyphenated C. Standards. The work of creeling bales and removing or doffing delivery rolls is constant, even though the yardage contents vary. The work of watching for and properly handling a mill cut is changeable because the number of cuts is not the same per bale. The work of preparing starch batches varies in proportion to the machine speeds used. The machine speeds are selected from the variable speed transmission to suit weather, cloth, steam, and operating conditions. Thus, the starch mixing elements are correlated with the machine speeds used. There is considerable A.I.T. at the slower machine speeds, but it is eliminated at the higher speeds.

Procedure.—The next step is to segregate the job into its component parts. Figures 21 and 22 show all elements connected with the entire starching

(Continued on page 273)

THE BLANK CORPORATION
MASTER OBSERVATION SHEET

STUDY No. 114

DEPT. NO. 7F DEPT. NAME TAPE DATE WRITTEN SEP'T. 17, 19—

PART NO. SH4-9 PART NAME OUTER CASING TAPE

OPERATION COAT CLOTH FOR FULL PENETRATION OPER. NO 2

MATERIAL 40" WIDE STYLE G. CLOTH IN ROLLS 2800 TO 3200 YDS. FROM MILL. CALL 3000 YD

OPERATOR 7-236 VIC. BROWN ~~FEMALE~~ MALE STARTED 6^{00} 9-3-19 STOPPED 3^{00} 9-3-19 ELAPSED 25 HRS.

MACH. NO. 852 MACH NAME STARCH MACHINE.

TOOLS 1500 YARD DELIVERY ROLL. 5 TO 9 CUTS PER MILL ROLL. CALL 3 CUTS PER 1500 YARD ROLL. SPEED FEED VARIABLE ACCORDING TO WEATHER.

CREDOR STD * PER * %A.I.T. VARIABLE %N.W.T. SEE CHART

ELEMENT	REFERENCE	DESCRIPTION OF ELEMENTS	NORMAL	REST	COUNT	ALLOWED EXTERNAL	ALLOWED INTERNAL
A	29-8-6	Turn on steam in cylinders.	.778	10%	1/8	.107	
B	8-8	Start motor & machine.	.830	11	1/8	.115	
C	8-22	Take water out of cylinders.	1.150	10	1/8	.158	
D	8-25	Scrape 2 machine rolls & apply wax.	1.24	13	1/8	.175	
E	6-4	Remove empty arbor at creel end of mach.	.798	11	1/2	.443	
F	1-22	Move supply bale to machine.	.526	14	1/2	.300	
G	9-11	Remove burlap wrapper & post yardage data	1.327	10	1/2	.730	
H	1-28	Roll bale to machine creel.	1.057	15	1/2	.608	
I	1-32	Prepare & roll bale up on ramp.	1.412	18	1/2	.833	
J	1-37	Place arbor & secure bale in creel.	1.050	12	1/2	.588	
K	2-3	Pass bale end over top machine bars.	.707	15	1/8	.102	
L	9-23	Pass bale end through starch rolls.	.764	12	1/8	.107	
M	14-3	Weigh 2 cans of starch & place on platform	.672	12	1.7		1.279
N	9-30	Fill extra barrel with cold water.	1.370	8	1.7		2.515
O	9-32	Turn on steam, add starch & stir.	2.253	14	1.7		4.370
P	11-9	Stop machine & tie on drag rope to bale end	1.667	12	1/8	.233	
Q	11-13	Pass rope between rolls. see KK	—	—	—	—	—
R	2-30	Start mach. & feed cloth to delivery end PMT=1.63@60	2.170	10	1		2.387
S	2-33	Stop mach. Up wood arbor & remove drag rope	1.820	13	1/8	.257	
T	3-2	Paste cloth end to wood center.	2.035	13	1	2.300	
U	3-6	Place wood arbor in machine.	.466	11	1	.517	
V	3-8	Adjust cloth & place on tension weight.	.716	15	1	.823	
W	3-11	Start machine & walk to creel.	.524	10	1	.576	
X		Starch 1500 yard of cloth P.M.T.= see % N.W.T.	—	—	—	—	—
Y	2-15	Skim off top of starch mix in barrel.	1.990	10	1.7		3.720
						8.972	14.271

REMARKS * SEE RECAP SHEET TS 114½

FOREMAN T.S.M GEN. SUPT.

FIG. 21.—The starching machine operation. Continued in Fig. 22.

THE BLANK CORPORATION
MASTER OBSERVATION SHEET

STUDY No. 114

DEPT. NO. DEPT. NAME DATE WRITTEN

PART NO. PART NAME

OPERATION OPER. NO.

MATERIAL

OPERATOR FEMALE MALE STARTED STOPPED ELAPSED HRS.

MACH. NO. MACH. NAME

TOOLS SPEED FEED

CREDOR STD. PER %A I.T. %N W T.

ELEMENT	REFERENCE	DESCRIPTION OF ELEMENTS	NORMAL	REST	COUNT	ALLOWED EXTERNAL	ALLOWED INTERNAL
		Brought forward				8.972	14.271
Z	29-11-7	Stir starch in barrel.	1.085	13%	1.7		2.084
AA	11-18	Fill starch trough with cooked starch.	.300	12	1.7		.571
BB	5-34	Stir starch in trough.	1.618	18	1.7		3.246
CC	10-26	Stop mach. after 1500 yds. P.M.T.=.75 @ 80 R	1.00	10	1		1.100
DD	10-28	Off tension weight.	.354	15	1	.407	
EE	10-29	Cut cloth at delivery end.	.678	12	1	.760	
FF	10-31	Remove lock nuts & remove wood arbor.	.623	12	1	.700	
GG	4-24	Move delivery roll down to floor.	.089	12	1	.100	
HH	5-13	Fold end & cut away 8 yards from roll.	1.153	12	1		1.290
II	8-15	Measure & post data to match creel roll.	1.355	10	1		1.491
JJ	5-21	Move roll away 10 feet to storage.	.299	18	1		.353
KK	12-13	Stop mach. & tie drag rope to last day's roll.	1.035	12	1/8	.145	
LL	12-15	Start mach. & pass rope to delivery mach. end	1.025	10	1/8	.141	
SS	1-5	Fill 2 pails with raw starch.	1.031	12	1.7		1.963
TT	6-15	Adjust cloth tension feed fingers.	1.650	12	1		1.850
		Sew Cloth.					
MM	7-11	Move portable sewing machine to job.	.131	12	1/2		.073
NN	7-1	Up 2 ends & place on sewing mach.	.984	11	1/2	.546	
OO	7-4	Sew 2 ends together.	1.175	10	1/2	.646	
PP	7-6	Arrange cloth at creel after sewing.	.604	12	1/2	.338	
QQ	7-8	Start machine & return.	.467	10	1/2	.257	
RR	7-12	Away sewing machine.	.131	12	1/2		.073
		Cuts.					
UU	3-17	Mark tell tale mark on cloth anticapating cut	1.217	10	3		4.017
						13.012	32.382

REMARKS Includes necessary walking

FOREMAN T.S.M. GEN. SUPT.

FIG. 22.—The starching machine operation. Continued from Fig. 21.

Element	External, minutes	Internal, minutes
A	.107	
B	.115	
C	.158	
D	.175	
E	.443	
F	.300	
G	.730	
H	.608	
I	.833	
J	.588	
K	.102	
L	.107	
P	.233	
R		2.387
S	.257	
T	2.300	
U	.517	
V	.823	
W	.576	
CC		1.100
DD	.407	
EE	.760	
FF	.700	
GG	.100	
HH		1.290
II		1.491
JJ		.353
KK	.145	
LL	.141	
MM		.073
NN	.546	
OO	.646	
PP	.338	
QQ	.257	
RR		.073
TT		1.850
Total....	13.012	8.617
		13.012
Grand total.........		21.629

operation. Since the operator will be paid for yardage doffed at the rear end of the machine, the series of C. Standards will be based on 1,500-yd. doffs. Since the creel bales contain from 2,800 to 3,200 yd., an average of 3,000 yd. will be considered. Since the delivery or doffed rolls are 1,500 yd. each, a count of ½ is specified for the 12 constant elements in the Count Column on the Master Observation Sheet. These 12 elements are *E*, *F*, *G*, *H*, *I*, *J*, *MM*, *NN*, *OO*, *PP*, *QQ*, and *RR*.

The count of ⅛ is arbitrarily set up for the 10 constant elements, *A*, *B*, *C*, *D*, *K*, *L*, *P*, *S*, *KK*, and *LL*, because it was felt that at least eight doffs should be obtained per day under bad weather and operating conditions.

It was found that one delivery roll of 1,500 yd. consumed 1.7 bbl. of cooked starch, hence the 1.7 ratio as indicated by the eight changeable elements, *M*, *N*, *O*, *Y*, *Z*, *AA*, *BB*, and *SS* in the Count Column.

Element *UU* specifies a count of 3 because this was the established average number of cuts found per 1,500-yd. doffed roll.

The 14 remaining elements, *R*, *T*, *U*, *V*, *W*, *CC*, *DD*, *EE*, *FF*, *GG*, *HH*, *II*, *JJ*, and *TT*, are performed only once per 1,500 yd.

The first standard to be built covers the constant work connected with one 1,500-yd. doffed roll. An extract of Master Observation Sheet data shows that the constant allowed Externals and Internals are as shown in the table on page 272. Based on that table the figuration is:

Externals and Internals for constant roll basis	21.629 min.
Element *X*. Run machine average of 130 F.P.M.	
$\frac{1,500 \times 3}{130} = 34.6$ min. P.M.T. for attention basis.	
Add 1½ per cent attention for element *X*.	
34.6 min. × .015 @ 80R. = .692 min. N. + 8 per cent rest	.747 min.
	22.376 min.
Extra walking = 2½ per cent × 22.376 + 10 per cent rest	.615 min.
	22.991 min.

Call 23 min. constant C. Standard per doffed roll.

The next standard to be built covers the changeable work connected with the operation. This standard will be based on the yardage delivered. The proper Internal elements selected from the Master Observation Sheet are

Element	Internal, minutes
M	1.279
N	2.515
O	4.370
Y	3.720
Z	2.084
AA	.571
BB	3.246
SS	1.963
	19.748

Changeable Internals for the yardage basis	19.748 min.
Use the same machine time as for first standard = 34.6 min.	
Add $1\frac{1}{2}$ per cent attention for element X	
34.6 min. $\times$ .015 @ 80R. = .692 min. N. + 8 per cent rest	.747 min.
	20.495 min.
Extra walking = $2\frac{1}{2}$ per cent $\times$ 20.495 + 10 per cent rest	.564 min.
	20.059 min.

Call 21 min. C. Std. = 21/1,500 $\times$ 100 = 1.4 min. C. Std. per 100 yd.

The third standard to be built handles the cuts as specified by element *UU* on the Master Observation Sheet. The work for this element is considered the most important item. The operator is required to anticipate each red flag about 50 ft. ahead of time, mark zigzag pencil lines on the cloth preceding the cut, and place the red flag on the mill cut again when the latter reaches the doffing roll. Therefore, the time of 4.017 min. is arbitrarily increased by 12 per cent and called 4.50 min. for the three cuts per 1,500-yd. roll or 1.5 min. C. Std. per cut. Increasing this last time allowance dispels any feeling that the operator does not have time enough for this important item of work.

As we have previously stated, weather and other conditions make it necessary to run the machine at speeds best suited to operating temperatures, etc. On days when the machine must operate slowly, the operator has considerable A.I.T. Therefore, the Credors that he produces must be protected by a scale of % N.W.T. allowances directly proportionate to the various F.P.M. machine speeds. A tabulation will be computed for the changeable % N.W.T. The shop operates 8 hr. per day but, since the operator must clean his machine before leaving, the maximum productive time is $7\frac{3}{4}$ hr. or 465 min. per day.

A recapitulation of the three standards built follows:

Constant standard for one 1,500-yd. delivered roll	= 23.0 min.
Changeable standard for 1 yd. = .014 $\times$ 1,500 yd.	= 21.0 min.
Changeable standard for one cut = 1.5 $\times$ 3 cuts	= 4.5 min.
Total hyphenated standard for one 1,500-yd. roll	= 48.5 min.

If the operator performs the total C. Standard at an 80 effective speed, he will perform the work for one delivered roll in 48.5 min. $\times$ .75 R.F. = 36.375 actual min.

$$\frac{36.375}{1{,}500} = .02425 \text{ min. required per yard}$$

$$\frac{465}{.02425} = 19{,}175.3 \text{ yd. produced per day at } 100\% \text{ N.W.T.}$$

We now know the operator's maximum 80 C. Hour production, but we must determine the machine speed that attends this performance. To learn the machine speed, we must find what percentage of the standards is Externals because these prevent the machine from operating continuously throughout the day. To do this requires a partial reworking of the Master Observation Sheet figures as follows:

	Externals, minutes	Internals, minutes
Master Observation Sheet totals	13.012	32.382
Attention for element X	......	.747
Extra walking for Externals =		33.129
13.012 × .025 + 10 per cent rest	.359	
Extra walking for Internals =		
33.129 × .025 + 10 per cent rest	......	.911
	13.371	34.040
		13.371
		47.411

$$\frac{13.371}{47.411} = 28.2 \text{ per cent External}$$

Therefore 28.2 per cent of 465 working min. per day is 131 min. of External work where the operator has 100% N.W.T.

465 working min.
131 External min.
334 available machine min.

$$\frac{19{,}175.3 \times 3}{334} = 172.2 \text{ machine speed in F.P.M.}$$

Table 6 is next prepared and the first entries of 172.2 F.P.M. and 19,175.3 are made for 100% N.W.T. The data in the three columns are predicated on an 80 effective speed to protect the % N.W.T. figures.

Column 2 figures in Table 6 are obtained by multiplying column 1 data by a factor of 111.33. This factor is obtained as follows:

$$\frac{19{,}175.3}{172.2} = 111.33$$

Column 3 in Table 6 is solved by reducing the yardages to Credors (see p. 274) and by using the % N.W.T. formula (as outlined in Chap. IX) expanded to represent one day of 7¾ hr.

$$\frac{48.5}{1{,}500} = \frac{.03233 \times \text{column } 2 \times 100}{80 \times 7\frac{3}{4} \text{ hr.}}$$

The reader may simplify the figuration for column 3 and possibly avoid small errors in figuration by reducing the foregoing data to a single factor and then multiplying it by column 1. We shall call it factor t, where

$$\frac{48.5 \times 111.33 \times 100}{1{,}500 \times 620} = t = .581$$

TABLE 6

Machine, F.P.M.	Yards made per day	% N.W.T.
172.2	19,175.3	100.0
170	18,926	98.7
160	17,813	92.9
150	16,700	87.1
140	15,586	81.3
130	14,473	75.5
120	13,360	69.7
110	12,246	63.9
100	11,133	58.1
90	10,020	52.2
80	8,906	46.4
70	7,793	40.6
60	6,680	34.8
etc.		

Checking Card.—At the end of the day, the number of finished delivery rolls doffed, the total yardage produced, the total cuts handled, and the machine speed used are specified on the checking card. The foreman establishes the machine speed for each day and not only marks the speed on the checking card but also writes in the thermometer reading for the day. The machine usually operates at a speed of 130 F.P.M. which thus accounts for the 34.5 min. P.M.T. used in the foregoing figurations.

Briefly summarizing the starching operation: The three C. Standards and the scale of % N.W.T. cover all operating conditions that might arise. The favorable conditions are large creel bales consisting of long yardages, few cuts, and high machine speeds. The unfavorable conditions are small creel bales, maximum cuts, and slow machine speeds. The C. Standards proved to be flexible enough to meet equitably all variations of conditions.

This chapter incorporates so many of the principles of time study thus far treated that it will behoove the reader to go over all figurations in the chapter, check them, and note carefully the logic of the various steps taken in the solution of the unusual time studies outlined.

Problems

1. An operator is penalized, by means of a quality factor, for some bad castings he produced during the day. He produced 98½ per cent good castings in 8 hr. on standard. The good and bad castings were covered by a

1.4-min. C. Std. per casting and the operator was credited with a 70 C. Hour performance for the sum of good and bad castings. How many bad castings did he produce? What was his penalty in Credors?

2. With reference to page 266 of this chapter, the assembly operator is given the following shop orders to complete:

Make 15 units of No. 3 size, each consisting of 12 sections.

Make 25 units of No. 4 size, each consisting of 4 sections.

The operator's time in the shop was 8 hr. and he was on standard all day with the exception of 27 min., during which period he was allowed "day work" because he had to wait for necessary castings. What is the operator's Credor-hour performance for the day?

3. Referring to Table 6 on page 276 of this chapter, show the figurations and answers for columns 2 and 3 for 85 machine F.P.M.

4. With further reference to Table 6, an 80 operator under rare operating conditions can service the machine at a speed of 172.2 F.P.M. At what speed should the machine run for an 85 operator in order to keep him fully occupied?

5. With reference again to the starching machine operation, the operator is on standard for 7¾ hr. out of his 8 hr. During that time he produced 9 delivery rolls, each containing 1,500 yd. The total cuts amounted to 36. The foreman set the machine at 130 F.P.M. for the day and consequently the operator was allowed A.I.T. What is the operator's Credor Hour? How many minutes of A.I.T. was he allowed?

Answers to Problems

1. The operator was on standard for 8 hr. and, since he was credited with a 70 C. Hour performance, he earned $8 \times 70 = 560$ Credors.

$$\frac{560}{1.4} = 400 \text{ total castings produced}$$

$$400 \times 98\tfrac{1}{2} \text{ per cent} = 394 \text{ good castings}$$

$$400 - 394 = 6 \text{ bad castings produced}$$

$$6 \times 1.4 \text{ min.} = 8.4 \text{ Credors penalty}$$

2. The operator was on standard for a period of 8 hr. − 27 min. = 453 min. During that time the Credors produced were

Number 3 size	15 total units	× 3.2 min. C. Std.	=	48 Credors
Number 3 size	180 total sections	× 1.4 min. C. Std.	=	252 Credors
Number 4 size	25 total units	× 3.8 min. C. Std.	=	95 Credors
Number 4 size	100 total sections	× 1.6 min. C. Std.	=	160 Credors
		Total effort expended	=	555 Credors

$$\frac{555 \times 60}{453} = 73.5 \text{ C. Hour}$$

3. Column 2 = $111.33 \times 85 = 9{,}463$ yd. per day
Column 3 = $.581 \times 85 = 49.4\%$ N.W.T.

4. $172.2 \times 85/80 = 183$ F.P.M. approximately

5. Yards produced $9 \times 1{,}500 \times .014$ min. C. Std. = 189 Credors
Amount of rolls made 9×23.0 min. C. Std. = 207 Credors
Total cuts handled 36×1.5 min. C. Std. = 54 Credors
Total = 450 Credors

Since the machine ran 130 F.P.M. the operator was allowed 75.5 % N.W.T.

$$7\tfrac{3}{4} \text{ hr.} \times .755 = 5.85 \text{ effective hours on standard}$$

$$\frac{450}{5.85} = 76.9 \text{ Credor Hour}$$

8 hr. in shop = 480 min.
Cleaning time = 15 min.
Actual time on standard = 465 min.
465 × .755 = effective time on standard = 351 min.
N.I.T. allowed = 114 min.

Chapter XV

Although the establishment of wage scales is a management specification, the time-study department is often called upon for help in supplying certain data to assist in the task. That help should not concern the maximum and minimum wages to be paid, nor the scale of intermediate rates in the range; but, when they have been officially determined by others, the T.S.M. can intelligently fit them to the various operations that he has time-measured in the plant as an impartial agent.

Chapter XV outlines the procedure to be observed in attaching proper weighted values to each operation so that the different wage-scale rates are consistently applied.

CHAPTER XV

ESTABLISHING WAGE SCALES

In Chap. V, it was stated that the T.S.M., when he is dealing with labor, should have no authority to include the subject of wages to be paid. The question of financial incentives is solely a management problem and the announcements of money to be paid should come from persons other than the members of the time-study department. This ruling leaves the T.S.M. free to discuss the various jobs exclusively from the angle of time study. Consequently, any questions that are asked or complaints that are made to him by workers cannot be obscured by the subject of what wages should be paid for the time allowances created.

The success of any wage-incentive plan results from its features that prove attractive to labor. The plan may have many virtues, but they are all subordinated to the main issue, which concerns the monetary reward offered for the extra expenditure of effort. If the incentive is not attractive to labor, the full measure of success offered by time-study analysis cannot be attained.

It is in the light of this success that the T.S.M. becomes indirectly interested in wage scales. Through his analysis, he has placed many time, mental, and physical values on the various operations encountered in the plant. The weights of the values were peculiar to the elements of work involved. Since he is thus able to establish values, his suggestions regarding the weight of financial values to be attached to the various operations are often sought by the management after it has determined the extreme limits of a proposed wage scale.

Labor is a commodity purchased by employers. Like any other commodity, its value depends upon the law of supply and demand. This law is contingent upon economic conditions, and, since these change periodically, the values of labor also change.

Many things influence economic changes. Chief among them is the public who purchases the articles produced by labor. Since

the public is made up of labor, it seems paradoxical that labor cannot maintain its own values.

Labor values are paid for in the form of salaries or wages. They are paid from production. If the production, from the standpoint of volume and profit, cannot be made continually attractive to employers, then labor values cannot remain at a given level. As stated in the first chapter, modern employers now know that workers must be loyal and content and that, to secure this happy industrial situation, they must be well paid in addition to other advantages offered to them in the way of ideal operating conditions, etc.

Labor should receive its wages through the medium of a wage-payment incentive plan. There are many types of plans in use, all of which have the same aims or the same broad underlying principles. Some of the plans are simple in operation and others are complex. The author is not recommending any particular plan but unquestionably some are better than others. Several kinds of plans should be carefully investigated before any one of them is selected and adopted for use.

Industrial surveys show that of all the incentive plans in use in the United States, 75 per cent are piecework plans. Perhaps piecework plans hold this large majority because they are the easiest to install or because they are better known than other plans.

There are several disadvantages in a straight piecework plan. One of the main troubles accrues from the necessity of adjusting piecework prices to meet the fluctuating economic changes. These changes affect the purchasing power of the dollar which requires the periodical adjustment of piecework rates. This adjustment not only requires time and expense but also creates in the mind of labor a feeling that it cannot depend upon piecework prices. Straight piecework plans do not guarantee a minimum wage, which has its disadvantages whenever there is a scarcity of labor. Also, few piecework plans reward indirect labor in a definite, mathematical manner for its contribution to the welfare and success of direct-labor performance. On the other hand, piecework plans for productive work are simple, easy to install and understand, and require comparatively small expense to operate. Since there is a definite fixed price attached to each piece of work produced, the operator can readily figure his day's pay.

To offset some of the undesirable features of piecework plans, many factories are installing premium or bonus plans that are based on time instead of money. Some of the plans may cost slightly more to operate but perhaps offer advantages that outweigh the additional operative cost.

So far as time-study work is concerned, there are four fundamentals connected with manufacturing: (1) quality of work; (2) quantity of work; (3) economy in the use of materials and equipment; and (4) the proper reward to both employers and employees. To attain the best results from these four basic items, a satisfactory wage-payment incentive plan should be comprehensive enough to meet and dispose of them successfully. Such a plan will recognize many other things. Among them are

1. The plan should be understood by the average worker, who should be able to compute his own wages easily. Unless the operation is of unusual type, the operator should know at the end of each day just how much he has earned. Some plans are so filled with sliding-wage earnings, complicated charts, mysterious figuration, and other involved ramifications that the worker is never quite sure he is receiving all that he has rightfully earned.

2. The plan should be flexible enough to handle all odd time-study jobs or unusual production operations throughout the plant. Many departments in factories were not included in time-study work simply because the incentive plan in use was not flexible enough to cope with unusual time-study problems.

3. The plan should be of such character that its data are "served hot" to all concerned, not only as a record of performance but as a trend that can be controlled. To have cost control, the data must be supplied quickly, in sufficient detail to be effective and at a clerical cost that will not be prohibitive.

4. Indirect workers should be offered an incentive for extra effective effort. This incentive should accrue from a formula or from a definite ratio to volume produced or energy expended, and not from a fund arbitrarily dispensed. In almost every manufacturing plant, the indirect pay roll is relatively high in comparison to the direct pay roll and is therefore subject to proportionate savings.

5. The plan should lend itself to quick adjustment that may be occasioned by changes in economic conditions.

6. The plan not only should reward learners, in the form of new employees or those changed to new duties, proportionately for their efforts but should intelligently check and record their progress.

7. Employees who have grown old in the service of their employers and for physical reasons cannot produce as much as their younger shopmates should be fully rewarded for their daily effort.

8. A minimum hourly wage should be guaranteed to all workers. Thus, whenever a worker is forced to wait for materials, breakdowns, or other

causes beyond his control, he should not be penalized. This guaranteed hourly wage is called the base rate.

9. The incentive, over and above the base rate, should be attractive enough to the worker to warrant his continued interest and to stimulate his desire to achieve. It is felt that the incentive should be 25 to 35 per cent over the base rate. One automobile plant in the Midwest specifies 70 per cent over the base rates, which, when earned, brings the net daily wages slightly higher than the prevailing wage scale in that section for comparable automotive work. This high incentive ratio is satisfactory as long as the workers are kept on standard, but, whenever delays occur, the hourly earnings accruing from the low-base rates influence labor turnover. On the other hand, unless there is at least 25 per cent spread between the base rate and the earnings to be made from desired performance, some workers will not extend themselves for the small amount of extra money involved.

Regardless of the wage-incentive plan used, the preliminary step in establishing wage scales is to line up all work in the plant affected by time study. After this has been done, the different types of jobs are listed into departmental groups. When the groups have been separated into distinctive types of work operations, the operations are then considered for their individual weights or effort values by being placed into three general classifications: common, semiskilled, and skilled.

The consideration given to these three groups at this stage of the analysis should not include the subject of wages to be paid for them. In fact, at this point, they should be visualized from any angle except that of their money values.

A list of the departmental operations is then prepared, roughly classifying them into the three groups. Each of the three groups can be further subdivided into classifications such as low, average, high, and very high. The obviously unskilled operations are the first entries on the list and the skilled operations are the last entries added.

To facilitate the work of classifying the operations intelligently, a questionnaire can be prepared and each operation subjected to the prepared specifications. A questionnaire might cover specifications as follows:

Education required:

Read—write—or speak English.
Common—high—or technical school degrees.
Ability to read blueprints.
Ability to follow instructions, common to unusual.

Personal characteristics:
- Required sex.
- Suitable age.
- Physical fitness.
- Other traits necessary for the job.

Experience:
- Previous industrial experience.
- Skill required independent of past training.
- Length of time to become proficient on this job.
- Supervision required, minor, ordinary, close.
- Inspection required, minor, ordinary, close.

Job conditions:
- Floor—bench—machine.
- Rough—close—exacting.
- Light or heavy lifting.
- Machine hazards.
- Other hazards, ventilation, etc.
- Eye strain or dangerous work.
- Strain because of speed, noise, etc.
- General disagreeableness of work.
- Postures, normal to unusual.
- Fatigue, light, medium, heavy.
- Value of materials that may be impaired.
- Variety of operational elements.
- Repetitive, monotonous, routine.
- Use of unusual gauges or tools.
- Handling of more than one machine.

General:
- Personal tools required by operator.
- Job set up and controlled by operator or others.
- Possibilities of advancement to better job.
- NOTE: Consider also the 77 listed items in Chap. V.

When all the operations have been classified according to the foregoing specifications, the operations are now ready for the application of money values commensurate with the weight of each operation.

Wage levels for various trades are fairly definite in industrial centers. The variation of levels between industrial centers may be influenced by the cost of living, by the labor supply in different communities, or by many other things. If a trade is seasonable or if weather conditions prevent steadiness of work, the wage levels are apt to be higher to compensate in part for periods of

enforced idleness. Ordinary competition tends to stabilize wage levels in communities, as do state labor reports and labor unions.

It is interesting to note that many labor unions now look upon time study as an equitable means of measuring and establishing energy values that they themselves cannot clearly express when they are bargaining for proper returns for the worker. The unions feel that the trained T.S.M. is an impartial agent in setting up tasks and that, in the interests of his own job, he is anxious to have the workers receive substantial wages as an incentive to meet and maintain the standards he has set up.

If competition is keen, the employer, because of his financial position, may not be able to pay maximum wages for the manufacture of his product. His lack of continuous demand and small profit margins compel him to pay less for a given task than is paid by other employers in more fortunate circumstances. The hard-pressed employer often has to figure backward from his selling price, profit margin, fixed charges, material cost, and overhead; the remaining amount left for labor, although not adequate, is all that he can pay to his employees for their productive effort. Unless that situation can be changed, he can never have ideal manufacturing conditions, because his labor turnover will be high.

When the various weekly or daily wages to be paid for an 80 performance have been determined for each of the classified operations, the wages are converted to an hourly basis. These hourly wages are then tentatively attached to the operations according to their values. After this has been done, the incentives are subtracted from each hourly wage, thus establishing the particular base rate to apply to each operation. For example, assume that \$.525 per hour is to be paid for an 80 performance for a certain operation and that it includes a 25 per cent incentive; what is the base rate?

Solution:

$$\frac{\$.525}{1.25} = \$.42 \text{ base rate}$$

The percentage of incentive allowed over a base rate should be constant for all operations in the plant—*i.e.*, if 25 per cent incentive is established, it should apply to every job. The use

of different percentages for incentives for the same or different jobs or departments leads to confusion and errors.

The base rates assigned to each operation should be refined by specifying them in 3-ct. increments, each of which are evenly divisible by 60. This simplifies cost work. Not only do base rates under this policy result in short, even numbers after division, but less chance of error in cost figuration is expected, because the office clerks do not use as many figures when punching computing machine keys. Thus, the 3-ct.-by-60 increments are

Base Rates per Hour in Dollars	Credor Cost
$.21	$.0035
.24	.004
.27	.0045
.30	.005
.33	.0055
.36	.006
.39	.0065
....	....
.60	.01
.63	.0105
.66, etc.	.011

If 3-ct. divisions are too much, then 1½ increments divisible by 60 can be used which will result in even but longer numbers. For example:

$.21	$.0035
.225	.00375
.24	.004
.255, etc.	.00425

Before the base rates established for the various operations are actually approved, they should receive a final check to see that the base rates granted to one department are neither higher nor lower than those of another department for the same operations or operations that may be directly compared.

Many incentive plans specify that only one base rate can apply to some given operation, whereas other plans allow the use of more than one base rate to penalize or reward certain operators. From the standpoint of true operational costs, only one regular base rate should be specified per operation.

The importance of having base rates that are evenly divisible by 60 becomes manifest when Credor Costs are determined.

When an hourly rate is divided by 60, the rate per minute is yielded as its quotient. Since a Credor is a minute's worth of work, it follows that 1/60th of a base rate is the cost of one Credor. Thus, we have the formula:

$$\frac{\text{Base rate}}{60} = \text{Credor Cost}$$

As explained many times in the foregoing chapters, Credors represent the energy values necessary to complete a task. When the base rates have been assigned, definite monetary values for the task are placed on the Credors. This establishes another formula:

$$\text{Operational cost} = \text{C. Std.} \times \text{Credor Cost}$$

For example, if a 2-min. Credor Standard is built for some particular operation carrying a 48-ct. base rate, the cost of the operation becomes

$$\text{2-min.} \times .008 = \$.016 \text{ direct cost}$$

A joint use of the two above formulas is

$$\frac{\text{Base rate} \times \text{C. Std.}}{60} = \frac{\$.48 \times \text{2-min.}}{60} = \$.016 \text{ direct cost}$$

This method of figuration holds true for all direct-standard cost figuration where there is a normal or better performance, *i.e.*, the performance must be 60 C. Hour or more. Less than 60 C. Hour becomes subnormal performance, which is explained in Chap. XVII.

If a new wage-incentive plan is being installed in a plant previously operating on a time or day-work basis, and the past hourly earnings of the operators are to be increased under the new plan, the full amount of incentives offered may not be allowed to all of the operators. To amplify this statement: In day-work shops there are always some operators who, by reason of their relationship to higher shop officials, superior ability, or other advantages, may be receiving higher hourly wages than their less fortunate shop brethren who are engaged on the same kind of work. When the base rate for that work is established, it may not be predicated on the highest hourly wages that had been

paid, because when the other lower-paid men on the same work attained 80 C. Hour, they would be earning much more than the prescribed incentive percentage. For example, in a case where two men were engaged on the same type of work, one of them, who was paid 49½ cts. per hour, was receiving 10 per cent more than the other on the old basis; if a 25 per cent incentive was set up on a base rate of 49½ cts., the lower-paid man would enjoy a 37.5 per cent increase when he reached 80 C. Hour. It would therefore seem advisable to base the 25 per cent incentive on the first man's 45-ct. rate, thus allowing the previously higher paid man to earn only 13.6 per cent over his old wages. If the latter man, under the old scheme, had been correctly paid in relation to his superior capacity, he will have no difficulty in exceeding an 80 performance and will thus perhaps maintain his wage differential over his slower rival.

It is often revealed by time study that certain operators on a day-work basis who were paid higher rates than their immediate fellow workers often have difficulty in meeting standards that the so-called slower men easily reach and maintain.

Many plants, when changing from one incentive plan to another more modern one, find upon the basis of estimated savings that they can afford to increase direct labor costs and thereby pass on some of the savings to the workers. Whenever this is possible, the new plan will receive a more enthusiastic reception and it will be assured of earlier success than if no added wage incentive is offered by the change. For example, in changing from a piecework system to a plan based on time savings, it is well, if possible, to offer from 5 to 10 per cent increased earnings over the old piecework prices.

One question that might arise is why greater savings are possible under one plan than under another. The answer is that correct time-study work applying to modern plans does not permit of building into standards many allowances hitherto granted. Generally speaking, a standard should include only those regular work elements that are within the operator's control. Standards should not include waiting for the arrival of the foremen, inspectors, setup men, repairmen, tools, or materials or other extraneous items of delay that are beyond the control of the operator. These delays are purely indirect inefficiencies and should be so charged. With these various delays omitted,

the standards can be materially smaller, hence greater direct savings. If the wage plan allows incentives to indirect workers, it is to their interest to keep delays at their irreducible minimum. Protection against delays is given to the direct operators by time off standard, by adjusted C. Hours, or by the many other ways that have been outlined in previous chapters.

One of the most modern ways of dealing with energy expended, is the N.W.T. method, which usually applies to a plan having as its genesis the basis of time rather than money. On manual or hand-machine times, the N.W.T. is 100 per cent. On P.M.T. operations that are less than 100% N.W.T., the incentive offered is directly proportional to the amount of energy required for the job. For example, assume that two operators are assigned to machines that carry 48-ct. base rates. Operator *A* must work 100 per cent to complete his cycles, whereas *B*, operating a power-feed machine, has 70% N.W.T. Further assume that the incentive for an 80 performance in either case is 25 per cent over the base rate. Each man can earn an 80 C. Hour, but the premium earned by *B* will be only 70 per cent of that earned by *A*. Thus,

A. \$.48 + (.48 × 25% × 100%) = .48 + .12 = \$.60 @ 80 C. Hour
B. \$.48 + (.48 × 25% × 70%) = .48 + .084 = \$.564 @ 80 C. Hour

The % N.W.T. basis can be applied to piecework prices and can thus obviate the necessity of constantly altering them when one operator performs simultaneously a combination of piecework jobs that is periodically changing.

After the piecework prices have been set up in the regular way, each price is multiplied by the % N.W.T. that covers the priced operation. This final price per operation remains unchanged regardless of the combination of different operations performed. The rate card which specifies the net piecework price also indicates the % N.W.T. for the operation. In selecting the combination of suitable jobs for an operator, the foreman contrives to find a group of jobs that will "load" the operator. If he is not always able to do this, the operator, because of his unused energy, cannot make as much on certain days as he does on the days that his total N.W.T. percentages are higher.

Because of work shortages, etc., it is often necessary to transfer a worker from his regular operation to another one specifying

a different base rate. This possibility is covered by the three rules, which, of course, can be modified to suit local plant conditions. The rules are

1. Any operator changed from one job to another for a period of less than 4 hr. shall be paid the base rate of his regular job whether that base rate be higher or lower than the base rate of the job to which he is transferred.

2. Any operator changed from one job to another for a period of 4 hr. or more, shall be paid the base rate of the job to which he is transferred, provided that the base rate of the new job is lower than the one from which he was transferred. In case the new job has a higher base rate, the operator will remain on the base rate of the old unless he producees at a 60 C. Hour minimum during the time he is working on the new job, in which event he will receive the higher base rate for the entire time of his transfer.

3. Any operator who is frequently transferred during the day from job to job will take the corresponding base rates, on a basis of the actual time spent on each job. If it is not possible to record accurately the amount of time spent on each job, he shall receive an average weighted rate for it.

With regard to these three rules, in rule 1, the 4-hr. clause allows the foreman to transfer higher priced men to cheaper operations without financial loss to the transferred men. However, as a penalty for doing this, the cost department charges to the foreman a base-rate adjustment which appears as an excess cost against him. If the men remain on the cheaper jobs longer than 4 hr., they will rightfully complain since their base rates are automatically changed to the lower basis. This might satisfy the foreman but will ultimately lead to trouble with his men. Transferring a slow or inexperienced operator carrying a smaller base rate to a higher base-rated job creates an excess cost unless that operator can produce a 60 C. Hour output. Rule 3 is more involved and will be fully outlined in Chap. XVIII.

Although an 80 performance is the average goal for industrial endeavor, the T.S.M. will often study workers who have become so proficient that their anticipated Credor Hours are much higher than 80 before application. A case of this kind is cited where several operators on an important operation in a plant manufacturing explosives were found by time study to be producing at an average of 105 C. Hour. These men had been operating under a piecework plan and were receiving high wages for their production, which the studies showed could not be increased. Nevertheless, it was decided under the new plan to pay them 5 per cent more for their regular performances. There-

fore, their new earnings were set up on 105 C. Hour performance (instead of the customary 80) by a base rate for these men predicated on 60 C. Hour or normal effort.

Referring to the last example, it is evident that the company lost money on the application of the 105 C. Hour operators who were paid more for a production that was not increased by the new plan. In this case, the men had been operating under a rate that had not been changed for several years and on account of the hazards of their work, the rising cost of living, etc., it was deemed advisable to grant wage increases to them. When the new plan was installed, these men were the first ones to be affected. They were considered as influential key men, and since they were not requested to produce more work for their increased earnings, the plan met with immediate success. The other operations in this department yielded both direct and indirect savings that easily made up the loss sustained by this one operation.

There are always "show" operations in every plant that are pridefully pointed out by the management as being the last word in efficiency and the T.S.M. may not be able to show any increased output as a result of his analysis and time measurement. If all operations were found to be in that ideal condition, there would be no need for time study. However, it is unquestionably true that, for every efficient operation, there are numbers of others that are subject to appreciable savings.

When base rates or piecework prices are officially released, they should be guaranteed against cut. If time studies are correctly taken, guarantees can be made. Incorrect time studies accrue from two fundamental liabilities. The first occurs when standards are built by untrained time-study men. The second occurs when standards are built by trained time-study men who must work under such high-pressure work schedules that they do not have sufficient time to analyze, measure, and check each job properly. The only difference between the two types of men is perhaps the consoling thought that the trained man will probably make less errors in his work.

Many higher plant officials look upon the movements of their time-study men with such suspicion that they feel the time-study work is not progressing as rapidly as possible and therefore assign such intensive schedules of job completions that even the excep-

tional man could not do full justice to the work. No doubt each T.S.M. had originally been picked for his many definite or latent possibilities and included in them was his honesty and willingness to work hard at all times. Notwithstanding this, if the T.S.M. is forced to work under high pressure to observe an improper work schedule, he cannot properly analyze each job and resorts to the practice of hastily measuring each job "as is" and devoutly hopes that his standards will be correct. Later on, if he discovers that some of his standards are loose, it is a very easy matter for him, in spite of the wage guarantees made, to prevent undue violation of his loose standards. One way is to warn indirectly the men working on the loose jobs that performances above 85 C. Hour will not be tolerated by the management. Another way is to create the belief in the minds of the inspectors and foremen that an 80 C. Hour performance for the inaccurate standards is a true barometer of quality and that, if this C. Hour is exceeded, quality will suffer. The T.S.M. may employ other sharp practices as a means of self-protection, but if he resorts to any of them the management cannot hope to enjoy the full advantages offered by time study. If the T.S.M. is lazy or does not produce as he should, he should be warned about his habits; if he does not respond to the warnings, he should be discharged or transferred temporarily to duties so distasteful to him that he is soon ready to display the necessary energy toward his work.

Many plants, because of faulty time-study methods, have piecework prices or time allowances that are very loose, although the production records do not reflect the discrepancies. An examination of the performance records of many jobs will reveal an evenness of earnings by all operators that seems to be ideal. As a matter of fact, a pronounced evenness of earnings should indicate to a shrewd observer that something is wrong with the time studies since nothing short of a fire or flood seems to disturb the fixed amount earned each day. The fixed amounts appearing in the records may be attributable to a plant policy which promptly cuts any time allowance when daily earnings exceed a stated amount. The operators soon learn what the "dead line" is for each job and faithfully abide within its limits. To test the validity of the dead line, the operators on particularly loose, unimportant jobs will occasion-

ally exceed the limit, knowing that, if the management is still alert and does cut the job a little, they still have enough latitude easily to make the same day's pay on a revised time-allowance basis.

Wage scales should be guaranteed against revision. One amendment to this is the necessity for general revisions upward or downward caused by economic conditions which affect all industries. A worker should not only be told but he should firmly believe that he can produce, without fear of wage or standard revision, as much work of a satisfactory quality as is possible without injury to himself or equipment. If economic conditions do dictate a change, only the base rates should be altered; the incentive percentage should remain unchanged regardless of conditions.

Wage scales can be guaranteed if the operations covered by them have standards that have been established by skilled time-study men and if "spot checks" have been made on the standards before their release for shop use. A guarantee is qualified by three things (aside from economic conditions):

1. Machinery.
2. Materials.
3. Methods.

When the guarantees are explained, the operators are told that, if new or different machines are installed, the rates are subject to change. Also, if materials are revised or methods radically altered, the operational elements affected will promptly be restudied and the revised time allowances found will be subject to 80 C. Hour attainment. The person who makes the guarantees should reiterate the statement that the plant is always seeking ways and means of meeting or anticipating competition by cheapening costs, but that this policy does not endanger operator wage scales. The three items, machinery, materials, and methods, are comprehensive enough to permit any official changes in standards that might be incorrectly established.

Questions

1. Name the four fundamental items connected with manufacturing of chief interest to the T.S.M.

2. Why should indirect workers be included in a wage-incentive plan?

3. What is the recommended minimum percentage of wage incentive over the base rate to be offered to direct operators for an 80 C. Hour performance?

4. In establishing a scale of base rates, how should they be graduated?

5. Name the three M's that officially permit time-study changes irrespective of guarantees made.

Problems

6. A time allowance of 2.5 min. per piece was set up for a certain manual operation. It was decided to establish a piecework price for an 80 performance based on a total wage of $5.76 for 8 hr. of production. What is the piecework price per 100 pieces?

7. In the automatic-machine department of a machine shop, the foreman is ready to assign a group of piecework jobs to be worked in combination by one operator. The foreman refers to his job and price list which is partially listed as follows:

PIECEWORK PRICES (CLASS P RATES)

Job	Actual hourly production @ 80	% N.W.T.	Piecework price, each	Net earnings per hour @ 80
1	150	50.0	$.002	$.30
2	30	15.0	.003	.09
3	12	10.0	.005	.06
4	140	70.0	.003	.42
5	15	25.0	.010	.15
6	30	62.5	.0125	.375
7, etc.	7.3	36.5	.030	.219

The foreman's shop orders on this particular day require the operation of the first three jobs in the above list to fill current orders. Any of the remaining jobs in the list can be run as the fourth job in the combination for the one operator because of low stock inventories. In assigning work to "load" an 80 operator, what other job, in addition to the first three in the above list, should be specified for the one operator? Show a list of the four jobs in the combination assigned. How much per hour should the operator earn by his four-machine performance?

8. In setting up a base rate for an operation, to which is attached a 25 per cent incentive, the operator will earn 8 per cent more than his present average wage of 62½ cts. per hour when he produces the anticipated output. What is the base rate to be specified?

9. In 8 hr. on standard, an operator makes an 80 C. Hour average. The job on which he worked carries a 45-ct. base rate. Each Premium Credor (those produced over a normal performance) is valued at $.005625. What is the operator's total wage for the day?

10. The function of a wage-incentive premium plan allows 75 per cent of the Credor Cost to the direct operator as premium money beyond a 60

Credor Hour performance. The other 25 per cent of the Credor Cost is set aside for an indirect premium fund. An operator on a job which carries a 42-ct. base rate makes 85 C. Hour for 8 hr. on standard. What is his total daily wage? How much money was set aside for the premium fund for the indirect workers?

Answers to Questions

1. The four fundamental items connected with manufacturing of chief interest to the T.S.M. are

Quality of work.
Quantity of work.
Economy in the use of materials and equipment.
Proper reward to both employers and employees.

2. The pay roll for indirect workers is relatively high in comparison to the direct pay roll and therefore is subject to proportionate savings. Just as direct workers are expected to display 80 Credors per hour, so also are the indirect workers. To this end, the number of indirect workers in the plant is often reduced and the effective efforts of the remaining indirect workers must be adequate to justify the smaller personnel. If the reduced number of indirect workers must handle a larger production than formerly, they should be rewarded for their expanded duties.

3. A percentage of 25 per cent is recommended as the minimum amount of incentive, in addition to the base rate, to be offered for the desired performance.

4. In establishing a scale of base rates, they should be specified in 3-ct. increments, each of which is evenly divisible by 60.

5. Machinery, materials, and methods are the three items that permit an official revision to an operation. The revision, caused by one or more of the three M's, does not mean less earnings by the operator, but the revised operation may call for more actual output of work for his 80 C. Hour effort.

Answers to Problems

6.

$$\frac{80\text{ Credors} \times 8\text{ hr.}}{\text{C. Std.}} = \frac{640}{2.5\text{ min.}} = 256\text{ pieces per day}$$

$$\frac{\$5.76}{256} \times 100 = \$2.25\text{ price per 100 pieces}$$

7. The foreman is interested in "loading" his 80 operator so that no % N.W.T. excess costs will appear against him on the cost sheets. He sees that the sum of the % N.W.T. for the three jobs is only 75% N.W.T. To make up for the Available Idle Time, he selects the 25 per cent or No. 5 job to establish a full complement of machines for 100% N.W.T., as follows:

Job	Actual hourly production @ 80	% N.W.T.	Piecework price, each	Net earnings per hour @ 80
1	150	50	$.002	$.30
2	30	15	.003	.09
3	12	10	.005	.06
5	15	25	.010	.15
		100		$.60

Since the operator is "loaded" under the above four-job assignment, he makes 60 cts. per hour.

8.

$$\frac{\$.625 \times 1.08}{1.25} = \$.54 \text{ base rate assigned}$$

9.

$$\begin{aligned}
80 \text{ C. Hour} \times 8 \text{ hr.} &= 640 \text{ total Credors earned} \\
60 \text{ min.} \times 8 \text{ hr.} &= \underline{480} \text{ min. on standard} \\
& 160 \text{ Premium Credors earned} \\
160 \times \$.005625 &= \$\ .90 \text{ total premium earned} \\
\$.45 \times 8 \text{ hr.} &= \underline{\ 3.60} \text{ wages at base rate} \\
& \$4.50 \text{ total day's wage}
\end{aligned}$$

10.

$$\begin{aligned}
85 \text{ C. Hour} \times 8 \text{ hr.} &= 680 \text{ total Credors earned} \\
60 \text{ min.} \times 8 \text{ hr.} &= \underline{480} \text{ min. on standard} \\
& 200 \text{ Premium Credors earned}
\end{aligned}$$

$$\$.42/60 = \$.007 \text{ Credor cost} \times .75 = \$.00525 \text{ Premium Credor value}$$

$$\$.42/60 = \$.007 \text{ Credor cost} \times .25 = \ .00175 \text{ Fund Credor value}$$

$$\begin{aligned}
200 \times .00525 &= \$1.05 \text{ total direct premium} \\
.42 \times 8 \text{ hr.} &= \underline{\ 3.36} \text{ wages at base rate} \\
& \$4.41 \text{ total day's wage} \\
200 \times \$.00175 &= \$.35 \text{ earnings for indirect fund}
\end{aligned}$$

Chapter XVI

When a number of men have been called together preparatory to an important assignment, the immediate and lasting success of the assignment depends largely on the last-minute instructions given. The person who gives the final instructions should know what to say and how to say it in the most convincing manner.

Making an application is the act of starting off a group of men on a wage-incentive plan. If that plan is new to them, its reception should be received with enthusiasm. The program of building enthusiasm begins on the day that the T.S.M. first enters a department and must be fully developed and sustained up to the point of application. If the application is properly made, the enthusiasm on the part of the participants will continue.

CHAPTER XVI

MAKING AN APPLICATION

When the operations for a department or for a group of operators have been time-studied and the standards for them are ready for use, the ceremony of starting the operators off on the new or revised plan is called "making an application."

Although it is advisable to have the standards ready for all jobs before a departmental application is made, it is not always the best policy to wait for the recurrence of certain jobs that are not regularly specified on shop order schedules in order to make the installation complete. These infrequent jobs will delay the application too long and tend to dissipate the enthusiasm that the T.S.M. has worked up on the part of all who are to share in the new plan. The infrequent jobs can be studied after the application—in fact, the operator can be told that he is working on standard, that the time allowance or price will be ready before the end of the day, and that he will be advised of it before quitting time. If the T.S.M. later finds that he cannot complete any of the standards as promised, he should, without deviation from the rule, so inform the operator. This rule will disarm any suspicion the operator might have that he was encouraged to make a day's demonstration and that his standard was calculated by that basis rather than by actual time study. If the T.S.M. knows in advance that he cannot complete the standard in time, the operator should remain on Time Off Standard or on the old allowance which is to be changed or confirmed.

Before an application is made, the T.S.M. should obtain a reference period from the management. This period is established from a study of previous inspection and scrap data, cost records, and other production memoranda, between specified dates, in which the quality and cost of production are representative of average conditions before application. This period should be based on average production results obtained before the T.S.M. started work in the department. The reference data are

used to check the old against the new data that are found after the department has been operating satisfactorily under the new plan or methods of revised time study.

Of prime importance is the securing of "spot checks" on all standards before application. The only departures to be made from this rule are where the T.S.M. is thoroughly experienced because of his length of service in the plant, because of his intimate knowledge of the work, or because of his belief that certain operations, by reason of their similarity to others or their compilation from standardized time-study data, may be passed without check. The standards for operations thus passed should receive unusual attention for possible errors in the figuration.

In making a spot check, the completed Master Observation Sheet containing the standard is taken to the job, where the operation is completed exactly like the indicated sequence of the work elements which are again briefly timed and rated.

Before the test is started, the T.S.M. makes sure that the materials are conveniently placed, that all proper tools are in use, that machine speeds and feeds are according to the time-study data, and that the job is generally "tuned up" as it should be for the spot check.

In company with the foreman or superintendent, the operator is told that the standard is to be checked and that he should work at a brisk even pace during the demonstration. During the test, the T.S.M. should use his regular watch in addition to the stop watch. The regular watch is used to record the over-all time of the amount of work produced during the test, and the stop watch records the timings of each of the operational work elements, which are also rated. The stop watch also removes any delays that should rightfully be subtracted from the over-all time of the test. The test is continued until the official is satisfied that enough work has been completed to represent a fair spot check. Before computing the operator's Credor-hour performance, the T.S.M. advises the shop official of the ratings he made during the spot check, the proper average of which is compared against the C. Hour which is computed from the standard and the work produced.

The time of the day will influence the spot check. If observed in the late afternoon, the operator's accumulated fatigue will

slow up his performance. If the rest factors granted are correct, it is doubtful whether the average type of operator will equal an 80 Credor demonstration unless he is able to accelerate his effective speed in indirect ratio to the state of mental or physical tiredness usually sustained at that time of the day. In view of this, it may prove advisable to run spot checks on the most important jobs in the middle of the working day in order that the computed C. Hour of the test will closely approximate the over-all rating performance that was specified by the T.S.M. to the shop official, as mentioned in the preceding paragraph. If the spot checks are taken before or after midday, the estimated and actual Credor-hour performances may not agree. The divergence may be due to the underused or overused rest allowances of the operator during the test.

The ordinary types of manual operations are easier to spot-check than machine operations. On the former, the T.S.M. is chiefly alert to operator-speed variations and delays. On machine operations, especially the multiple-power-machine combinations, the T.S.M. must also clock the operator influence on machine interferences in addition to other P.M.T. details.

On operations containing variables, enough good, average, and bad types of materials should be worked on to make the spot check representative of actual working conditions. Thus, the quantities of variables produced during the test should be the same percentages as those specified on the Shop Observation Sheets in arriving at the weighted average normals allowed for varying work as outlined in Chap. X.

If standards for graduated sizes of product were built from tabulated or curve data, all sizes need not be spot-checked, but at least two or three of the popular sizes should be observed in company with the suitable plant official in order to prove the statement, "If one is right, all are right; if one is wrong, all are wrong." It is almost needless to state that standards built from curves or tabulations for graduated-size work should have representative spot checks conducted with unusual care.

When spot checks are run on certain operations, all work elements as listed on the Master Observation Sheet may not be performed during the test. Such elements as, "Oil machine once per day," "Change cutters every 350 pieces," etc., that

are not done during the final observation should have their Allowed Normals deducted from the allowed C. Standard when computing Credor-hour spot-check performance.

Before leaving any operations that were spot-checked, the T.S.M. not only should have all the work produced thoroughly inspected, but should have the shop official express his entire satisfaction with the standards that have been tested.

In conducting a spot check, the T.S.M. briefly retimes and rates each element appearing on the Master Observation Sheet, with the possible exception of incidentals. The normals thus confirmed should, after the rest factors and count data have been added, yield a total that agrees very closely with the standard specified. If it does not, the error will probably be found in the extensions of the normals into the External or Internal columns or in their sum. Misplaced decimal points cause most of the errors found in standards.

Having satisfied himself that the standards are correct, the T.S.M. makes arrangements for the application. If the plan is a new or modified one, it may not be desirable to apply all operations in the department with the initial application. Instead, only a few operators may be applied on the first day and their efforts supervised until they produce satisfactory C. Hours, after which other groups of men are applied.

The first operations in the manufacturing processes of the work are usually the ones selected for the application. If the new production that is called for by the time studies is much larger than formerly, the management may have to alter the previous schedules covering the source of supply and anticipate larger quantities in order that the applied operators will not be held up by material delays. For example, if the foundry department of the plant has fed into the machine shop a regular fixed amount of castings each week and it is found that this amount will not be sufficient for the new volume to be consumed, either more men must be put to work pending the arrival of the T.S.M. in the foundry or a backlog of casting supply must be created in advance of the first application.

Applying first the early operations of a process might build up banks of work that require larger floor space for storage until subsequent operation applications consume them. This condition is not as serious as the applications first made on final

operations which tend to draw materials faster than the unapplied earlier operations can supply. Therefore, the T.S.M. must select the operations and apply them in such order and frequency as to preserve a balanced flow of work.

During the whole time that he has spent in a department collecting time-study data and making contact with labor, the T.S.M. has made mental notes of the best operations to be first applied and the most favorable operators to become the initial purchasers of the plan. This consideration often outweighs all others and therefore dictates the exact operations to be selected for the application.

Applications should be made as soon as the starting whistle has blown in the morning. Prior to that time, all previously finished work is cleared away so that it does not interfere with the new work. Also, an ample supply of materials is positioned at each work station, together with all proper tools, etc.

Only those operators to be applied are requested by the foreman to attend the application talk. The superintendent of the plant should attend all applications in each department and should make the opening remarks about the new plan being undertaken. He points out its benefits to the workers and states that the management is wholeheartedly behind the plan and is thoroughly convinced that the standards granted for the operations not only are fair but can be easily met and maintained. He stresses his statements regarding the quality of work which must be preserved or bettered. He states that base rates have been set up for each job which will be announced by the foreman upon their return to work after the talk. The superintendent emphasizes the statement that the extra earnings or premium money as specified on the daily department records accrue from the base rates established and not from their old hourly basic rates which may be higher or lower than the official base rate assigned to each operation. He also might find it advisable to announce that those operators receiving basic hourly rates higher than the established base rate will be guaranteed their old earnings for a period of one or more months, but after that time they are subject to the new prescribed base rates which will allow them at an 80 performance to earn as much or more than they previously did under the old scheme. The superintendent also briefly touches on the time

allowance or standard guarantees and states that as evidence of good faith, the guarantee will appear in writing over a responsible signature in the form of a notice to be posted on the bulletin board. He closes by saying that the talk must be brief, that the men are being paid the base rate during the talk, and that, as soon as the T.S.M. has added a few time-study instructions, the men should start off on the new plan with an enthusiastic desire to make it succeed.

The T.S.M. then explains to the assembled operators that delays of 3 min. or more which are beyond the operator's control will be granted as credits to each operator affected, but that the plan does not recognize individual delays of less than 3 min. He also emphasizes the superintendent's reference to quality and states that one of the members of the inspection department has been in attendance during the talk and will see that the proper quality of work is observed. He closes his brief remarks by saying that he will remain on the job long enough to explain how much work is called for per hour by the new standards, show the operators how to compute their wages, and answer any questions they may ask pertaining to time study.

If the standards call for a normal output greatly in excess of the old amount, the T.S.M. should stay close to the application long enough to convince the operators that the standards can be met. It is far better to spend a few hours or a few days with the key men in a group to demonstrate the equity of a standard than to leave the application too soon and later find that many days or weeks were spent in securing 80 C. Hours that could have been reached sooner if a more concentrated attention had been given to the job immediately after the application talk.

Many applications are failures or are delayed in reaching anticipated performance because the management uses long-range methods of applying men to new plans by means of notices posted on factory bulletin boards. The installation of a new or revised plan is important enough to warrant personal contact with the men when starting it. A printed notice will likely cause one or more of the operators to feel that the person signing it is too timid to announce personally such an important issue. As a result, the majority of the operators in the department will will soon echo the sentiments of a few and all may deliberately place a limit on their efforts in order to learn what type of written

notice will succeed the first. As stated, the superintendent should attend all applications. If his available time does not permit this, he should at least attend the initial application in each department.

After the application talk, and after the foreman has advised each worker regarding his base rate and the earnings to be made, the T.S.M. spreads his time and attention over the applied group for the purpose of instruction. He may spend most of his time with one or two likely candidates in order to secure the desired Credor-hour performance from them, thus proving to the rest that the tasks are attainable.

The job of coaching operators for 80 C. Hour performance is much harder when the applied operators have previously operated on a daywork basis, because time-study figures usually prove that the average dayworkers operate at approximately 40 C. Hour performance. This being true, they must produce 60/40ths or 50 per cent more to equal a normal status, or 100 per cent more to equal 80 C. Hour performance. To many dayworkers, this seems at first to be impossible.

The average type of operator who has previously worked under a piecework plan having rates set up by untrained time-study men has been found by time study to be operating at 60 to 65 C. Hour before application of a modern incentive plan; therefore, the task of raising his effective efforts about one third does not require the coaching that was necessary for dayworkers.

The desired amount of daily production may not be reached the first day, but the results of the coaching on the part of the T.S.M. should cause operator C. Hours to increase each day until the 80 level is reached. After that time, the operation is turned over to the foreman who again takes charge of the work. In an earlier chapter, it was said that the T.S.M. has no authority over the operators insofar as their discipline is concerned, but that he must be able by his contact not only to secure proper time studies, but also to prove any standards that he has built. To do this, he must have the cooperation of the foreman, and this joint responsibility does not end until the standards have been satisfactorily demonstrated to all concerned.

Some operations do not bear the fruit of success for weeks or months after application. Many things cause this delay. However, if the standards have been spot-checked and the job

conditions are the same as when time-studied, the difficulty may lie in the operator's frame of mind. Some of the slower operators may feel that the tasks which have been set are unreasonable or are out of proportion to the extra money paid as incentives. The influence of these slower workers provokes what is known as "plugged" C. Hours.

A plugged performance results from a prearranged agreement among the operators to the effect that a fixed amount of production, slightly in excess of 60 C. Hour, will be produced each day. All operators subscribe to this policy and the ones violating the agreement are sometimes threatened with bodily injuries. The ring leaders causing this deliberate fixation of restricted output are not necessarily angry with the T.S.M. but are testing the resistance of the management to their contentions that the so-called 80 production cannot be met or that they should receive higher base rates for the work.

In meeting the situation of plugged performance, the T.S.M. first determines whether it is a case of standards or wages. If it is the latter, the correction of the trouble is a managerial problem. If the trouble lies in the standards, the T.S.M. may take production studies to prove the standards to the operators who might claim that demonstrations secured from short spot checks are not indicative of a full day's effort.

A production study starts at the morning whistle and lasts all day. If one day's checkup does not reveal the data desired, the study is repeated on the following day or days. The T.S.M. and the foreman both agree on the suitable operator to be studied and that operator alone is clocked during the study.

When the morning whistle blows, the stop watch is started and left running during the working hours of the day, during which time, all the operator's regular or irregular work movements are noted. The T.S.M. records a continuous story of the day's happenings, together with the accumulated watch readings. If the operation cycle is less than 1 min. long, the T.S.M. may not post the completion of each cycle but may record the number of pieces, the watch readings, and the ratings for every fifth piece of work produced. If the cycle is quite long, not only the watch readings for every piece produced but also the ratings of the performance in 5- or 10-min. intervals should be recorded.

Besides recording the watch readings and the cycle ratings, the T.S.M. lists all delays and their timings. To save much space and time, he may reduce some of the delay descriptions to symbols, for example:

R. Went to rest room.
D. Obtained drink of water 50 ft. away.
T. Talked with other men—no delay.
Td. Talked with other men—stopped work.
Pa. Paid poor attention to job.
etc.

An additional stop watch can be used to retime about once an hour all work elements in comparatively short cycle operations. The additional watch can also be used to an advantage on machine operations to check the P.M.T. periodically during the day.

The speed of machines should be checked two or more times during the day; in fact, all other items which may be pertinent to plugged C. Hours should be duly recognized, timed, rated, and added to other postings. It is hardly possible to obtain too many data, but a decided lack of data makes a production study useless so far as its full value in straightening out a problem of restricted production is concerned.

Upon the completion of the production study, the data are segregated into groups. The work produced, together with productive timings and ratings, is shown in one section and the delays and interruptions are shown in another. The watch readings covering the operator's personal necessities are compared with the 2½ per cent official allowance and, if they exceed that percentage, the total difference is interpolated to the additional production that should have been made. All other delays are then analyzed, and finally the regular work-element ratings are compared against those originally secured on the Shop Observation Sheets for that same operation.

If the production studies prove that it is a labor problem to be settled, the management must take the proper steps to correct it. One method of correcting a plugged performance was used by a mill overseer to break up an agreement some textile-mill operators had reached to limit their C. Hours to a fixed level. These operators had previously been operating under a piecework plan and their old production amounted to

an average 65 C. Hour, which they thought should be satisfactory on the new plan basis. In order to preserve that level, all operators agreed to produce no more work than called for by a 65 effort, and the daily records posted each day in the department showed that unvarying Credor-hour performance for each operator.

The mill overseer, in company with his foreman, went to the ringleader of the group and talked with him in a pleasant manner, causing a definite delay to the operator, the time for which was carefully noted by the foreman. Later in the day the foreman came back to the same operator and again caused him other delays. The true delays, when subtracted from his time on standard, should have yielded the same 65 C. Hour performance, although less work had been produced. However, the foreman arbitrarily allowed more than the exact delay time and as a consequence, the posted record displayed in the department on the following day indicated that the ringleader had apparently broken his agreement with his fellow workers by earning a 69.4 C. Hour performance. This breach of faith caused the other operators to equal and surpass the record set by their promise-breaking fellow worker and the desired 80 production was soon exceeded by all members of the group.

Another condition of plugged Credor-hour performance was traced to the management's failure to post the written guarantee mentioned during the application talk. The superintendent, after talking about the written notice, had inadvertently forgotten to carry out his promise. This failure caused the workers to discount the verbal pledge that had been made and the production volume increased only to the point where earnings from the new plan were on a parity with old earnings. When the cause of the restricted production was learned, a written guarantee was immediately posted. It read as follows:

NOTICE

With reference to the new wage-payment incentive plan which is being installed in this department, the management wishes to state that nearly all the operations have been time-studied and that time allowances known as standards have been prescribed for the operations.

In support of these standards, the management hereby guarantees, for a period of one year or longer, all standards against revision of the time allowances contained in them, unless official changes are made in any of the operations because of new developments in machinery, materials, or

methods. Machines of new or altered design; materials of different kinds, sizes, shapes, or weights; and methods of pronounced change are the only three items, aside from obvious mathematical errors, that will cause revisions to standards. Revisions thus made will result in modified standards that will still be subject to 80 C. Hour performance.

Base rates have also been established for each operation. These rates are likewise guaranteed against revision for a period of one year or longer, unless competition or general economic conditions require their suitable adjustment, in which event all rates will be subject to modification. Competition or other industrial conditions may dictate the wisdom of lowering manufacturing costs, but it is our purpose to lower costs by means of more output per man rather than decreased wages per man.

Premium is the reward for extra effort. It will be credited for satisfactory work in excess of the standard rate per hour no matter what the amount earned. Premium is figured on the base rate of the operation. In the case where an operator is receiving a higher rate per hour than the new base rate, only that amount of the premium credited will be paid which exceeds the difference between these two rates.

All delays of 3 or more min. which are beyond the control of the operator will be allowed at the regular base rate. All such delays, to receive credit, must be promptly reported at the time of their occurrence.

The Blank Manufacturing Co.

Date: ____________ per (Signature)

Manager.

The posting of this guarantee immediately increased the production to the volume desired. This notice is of the type that represented the actual sentiments of that particular management which were accordingly reduced to written agreement. Other managements, despite the three-M clause, are reluctant to commit themselves too strongly and therefore state their terms in shorter or more evasive statements that perhaps create suspicions on the part of the workers and limit their effective efforts.

Still another method of breaking up a deliberate, plugged Credor-hour performance is to transfer the offenders gradually to other isolated but previously applied departments, where the work carries smaller base rates. Their old places are filled with suitable types of learners or other skilled operators who can withstand possible overtures made by the remainder of the offenders who are also awaiting transfer. Refractory operators should be discharged. Others who are laboring under mental misapprehensions can many times be made into loyal and contented workers by considering them as industrial problems subject to proper analysis and solution.

After an application shows promise of further progress or is operating satisfactorily, the foreman then assumes sole responsibility for the standards, but the T.S.M. must still keep in touch with all jobs applied. Not only must he frequently refer to the reference period data to see that quality is maintained, but he must ascertain whether current costs are equal or lower than the estimated costs. The T.S.M. must also see that all persons directly or indirectly associated with the plan show a continued, enthusiastic interest in its welfare.

Questions

1. Should all departmental operations be completely time-studied and should standards be built for them before an application is made?

2. Why is it necessary to establish a reference period?

3. How much time should be spent in securing spot checks?

4. When a spot check is made, is the final standard as specified on the Master Observation Sheet always used?

Problems

5. A girl operator on a manual operation works 8 hr. per day. She has a .4-min. C. Standard covering a minor assembly operation. On the day in question, for reasons beyond her control, she had numerous intermittent delays, but during her remaining productive time she produced 1,450 assemblies. The delays, as recorded by the factory clerk, are as follows:

Time of the delays			Reason for delays
Start	Stop	Net minutes	
8:00	8:10		Wait for material
9:15	9:17		Wait for inspector
9:45	9:49		Wait for delivery of new file
10:05	10:08		Wait for inspector
11:20	11:30		Wait for material
1:15	1:25		Fire drill
2:07	2:09		Delay by sweeper
3:52	4:00		Allowance for special shop order

What is her C. Hour for the day based on her proper time on standard?

6. On page 310 in this chapter, it was stated that, as a result of the overseer's and foreman's interruptions, a plugged C. Hour was raised from 65 to 69.4. The actual delays (out of the 8 working hr.) amounted to a total of 9 min. In his net operating time, the ringleader produced 510 Credors. How many additional delay minutes were added to reflect the 69.4 C. Hour?

7. In a plant where a plan, based on time, was being substituted for one based on money, an operator requested information from the T.S.M. about his manual operation. Before the installation of the new plan, he had produced an average of 288 pieces per day of 8 hr. A new C. Std. of 2 min. per piece was specified. How many additional pieces of work should he produce per day to earn the 80 C. Hour performance? What was his old performance converted to Credor-hour effort?

8. In timing the various work elements during the spot-checking of an operation, the T.S.M. observed that the operator performed all elements, except one, at an effective speed higher than 80 performance. On the one element that was covered by a normal of .24 min., the operator appeared to be performing in an awkward manner because he required an average of .25 min. to complete this element in each cycle. The foreman, who was witnessing the spot check, asked three questions:

a. What is the operator's present effective speed on the slow element?
b. How fast should the element be performed to equal the desired 80 performance?
c. How much faster in percentage should the operator work to demonstrate an 80 for this element?

The reader is requested to answer the three questions.

9. The function of a wage-incentive premium plan allows 75 per cent of the Credor Cost to the operator as premium money for all Credors that are produced in excess of 60 C. Hour performance. One of the operators had been receiving a rate of 51 cts. per hour. A new base rate of 48 cts. was set up for his work. What C. Hour is necessary on his part to equal his old hourly rate?

10. A spot check is being conducted on a P.M.T. operation having elements as follows:

Element	Description	Allowed Normals	
		External, minutes	Internal, minutes
A	Move 50 castings		.012
B	Work element	.152	
C	Work element	.261	
D	P.M.T. = .499 minutes		
E	Attention		.002
F	Work element	.027	
G	Change cutter every 200 castings	.028	
H	Work element		.018
		.468	.032
			.468
44.1 % N.W.T.		Allowed C. Std.	.500

The spot check ran for a period of 30 min. and, although during that time elements A and G were not performed, a quantity of 36 pieces was produced. Upon the basis of an adjusted C. Standard, what was the operator's C. Hour spot-check performance?

NOTE: The % N.W.T. must also be adjusted.

Answers to Questions

1. It is preferable to have all standards built for a department before the first application in it is made. However, there may be many circumstances that will cause a modification of this rule. The contact of the T.S.M. has stimulated an enthusiasm on the part of all concerned to try out the plan. If this enthusiasm is allowed to reach its saturation point before the first application is made, a psychological reaction may take place which might impair the immediate success of all applications in the department. Other circumstances might arise from the desire to apply a small group of operators and to watch the results before further time-study steps are taken; from the possible value of having the T.S.M. still timing jobs in the department so that his presence might be useful for advice on previous applications, etc.

2. A reference period should be obtained without exception. A new or revised wage-incentive plan is installed for cost reasons, for better control, for better working conditions, and for many other reasons. To measure the actual benefits secured by the new plan, some basis of comparison should be made possible. A reference period indicates the values which are obtained before the use of a new or revised plan and which can be compared against values found afterward.

3. Spot checks are the mediums used to prove standards. Not only must the T.S.M. satisfy himself as to their accuracy, but he must also satisfy the foreman or the other factory official who must ultimately assume sole responsibility for them. Therefore, enough time should be spent on each spot check to yield demonstrations that are convincing to all concerned. The time interval varies with the nature of the job being checked. A simple type of short cycle operation might be proved in 5 min.; other operations might require hours.

4. Yes, provided that all regular work elements as covered by the standard are performed during the spot check. The variable or incidental elements not performed during the test should be subtracted from the final standard, or the count data covering them should be reconciled with the quantity of work produced in the over-all time of the spot check.

Answers to Problems

5.

Time of the delays			Reason for delays
Start	Stop	Net, minutes	
8:00	8:10	10	Wait for material.
9:15	9:17		Wait for inspector. Not allowed.
9:45	9:49	4	Wait for delivery of new file.
10:05	10:08	3	Wait for inspector.
11:20	11:30	10	Wait for material.
1:15	1:25	10	Fire drill.
2:07	2:09		Delay by sweeper. Not allowed.
3:52	4:00	8	Allowance for special shop order.
45 min. Time Off Standard			

$$\frac{.4 \text{ min.} \times 1{,}450 \text{ pieces}}{(480 \text{ min.} - 45 \text{ min.})} = \frac{580 \text{ Credors}}{7.25 \text{ hr.}} = 80 \text{ C. Hour.}$$

6.

$$\begin{array}{lrl} \text{Working day} & = & 480 \text{ min.} \\ \text{Actual delays} & = & \underline{9} \text{ min.} \\ & & 471 \text{ actual min. on standard} \\ \dfrac{510 \times 60}{69.4} & = & \underline{441} \text{ allowed min. on standard} \\ & & 30 \text{ additional min. granted} \end{array}$$

7.

$$\frac{80 \times 8 \text{ hr.}}{\text{C. Std.}} = \frac{640 \text{ Credors}}{2 \text{ min.}} = 320 \text{ pieces for 80 C. Hour}$$

$$\begin{array}{rl} \underline{288} & \text{pieces old production} \\ 32 & \text{additional pieces} \end{array}$$

$$\frac{2 \text{ min.} \times 288}{8} = 72 \text{ old C. Hour performance}$$

8.

a. $\dfrac{60 \times .24 \text{ min.}}{.25} = 57.6$ C. Hour

b. .24 min. $\times$ .75 R.F. = .18 min. @ 80 C. Hour

c. $\dfrac{(80 - 57.6)}{57.6} \times 100 = 38.9$ per cent faster for 80 C. Hour effort

9.

$$\begin{array}{l} \$.51 \text{ old hourly rate} \\ \underline{.48 \text{ new base rate}} \\ \$.03 \text{ to be made up by Premium Credors} \end{array}$$

$$\frac{\$.48}{60} \times 75 \text{ per cent} = \$.006 \text{ Premium Credor value}$$

$$\frac{\$.03}{.006} = 5 \text{ Premium Credors necessary}$$

$$60 + 5 = 65 \text{ C. Hour necessary to equal old rate}$$

NOTE: A shorter formula for the above figuration may be used:

$$\text{C. Hour} = \frac{80D}{B} + 60$$

where D = the differential between operator's rate and the base rate in dollars

B = base rate in dollars

The reader should apply this formula to the above problem.

10. By reason of the fact that elements A and G were not done, the % N.W.T. must also be temporarily adjusted before the spot-check performance is computed.

Total Externals		= .468 min.
Minus element G		= .028 min.
Adjusted Externals		= .440 min.
Total Internals	= .032 min.	
Minus element A	= .012 min.	
Adjusted Internals		= .020 min.
Adjusted Credor Standard		= .460 min.

Upon the basis of the adjusted C. Std., the adjusted % N.W.T. is as follows:

$$\frac{Te + Ti}{\text{cycle}} = \frac{(.44 + .02) \times .75 \text{ R.F.}}{.44 \times .75 + .499} = 41.6\% \text{ N.W.T.}$$

The test ran for 30 min. but, since there is a trial 41.6% N.W.T. attached to the adjusted C. Std., the operator actually worked only

$$41.6 \text{ per cent} \times 30 \text{ min.} = 12.5 \text{ min.}$$

Therefore, based on his actual working time for the production of 36 pieces during the over-all time of the spot check (the watch was not stopped for foreign movements) his spot-check performance is

$$\frac{36 \times .46 \text{ min.}}{12.5 \text{ min.}} \times 60 = 79.5 \text{ C. Hour spot-check performance}$$

Chapter XVII

Chapter XVII discusses the flexibility that is required in time-study procedure in order to handle operators who cannot reach or maintain normal performance. You will find the Credor Hour Base principle quite valuable in handling learners or elderly employees who are quick to recognize the fairness of the modified rate basis because it justly rewards those incapable of demonstrating 60 C. Hour. Your slide rule becomes an important instrument in working the proportion problems covering Credor Hour Base specifications.

CHAPTER XVII

MODIFIED BASIS OF PERFORMANCE

When a piecework price is granted to an operation, a fixed money value is attached to the work being done. In straight piecework plans, this value remains unchanged regardless of the volume of work produced or delays suffered by the operator. Thus, the work produced has a definite direct cost value despite operator conditions. Other piecework plans allow extra time or money to operators when delays beyond their control seriously affect their minimum daily earnings. These added allowances cause variations in the direct cost per piece.

Plans based on time instead of money have this same fluctuating cost liability, while others protect very closely the unit values per piece. Any plan that does make possible a standardized unit cost should also offer a means of cost control. To this end, a plan should have boundary lines within which standardized direct costs can be maintained even though the production volume varies from the index set up. The extent of permissible limits of variation may be more under the operation of one plan than under that of another. If the variation falls below the minimum side of a boundary line, the difference beyond the line should be considered as a controllable excess cost.

Throughout these chapters we have recommended a lower limit for the effectiveness of an average operator's performance. This effectiveness is called 60 C. Hour, because it compares with the performance of a 60-min. clock on the wall. Since a clock offers a universal means of time measurement that is neither too fast nor too slow, so the equivalent effort of labor therefore should be considered in direct comparison. Thus, 60 C. Hour becomes the lower limit for a modern wage-incentive plan, and it is upon this basis that base rates are established.

In Chap. XV it was explained that a Credor Cost is found by dividing the base rate by 60. Unless an operator can produce 60 Credors of work per hour, he is not normal and therefore

is not entitled to the regular base rate which determines the standardized direct cost of the operation. Consequently, if an operator is subnormal, his basis of performance should be modified and a lower base rate assigned to him that will protect Credor Costs. Subnormal operators are those who, by reason of advanced age, mental, or physical ability cannot produce 60 Credors per hour. New operators or those transferred to different jobs also fall within the subnormal classification.

Operators who are new in the plant or who have been transferred to different tasks cannot be expected to produce 60 Credors of work per hour at the outset. However, these learners should be given an incentive accruing from a lower base rate that will stimulate them quickly to reach and surpass a normal performance. Since the efforts of a learner are subnormal, his performance will be identified by the legend, "Credor Hour Base." If the word "base" is omitted, it is understood that he has reached the normal status.

A Credor Hour Base that carries a relative starting rate is set up for learners to protect Credor Costs. If it is found from past experience that a learner on a certain operation usually averages a 50 C. Hour for his first week's effort, he should receive 50/60ths of the regular base rate as his initial or starting rate. This starting rate should fall within the 3-ct. 60 base-rate range as explained in Chap. XV.

Example.—Learners on a particular job that carries a 39-ct. base rate usually show an approximate 50 C. Hour for their first week's effort. What is the starting rate?

Solution:

$$\frac{\$.39 \times 50}{60} = \$.325. \quad \text{Call 33 ct. to observe rate scale.}$$

Example.—Based on a 33-ct. starting rate, what is the exact Credor Hour Base (C.H.B.)?

Solution:

$$\frac{\$.39}{60} = \$.0065 \text{ Credor Cost } \frac{\$.33}{.0065} = 50.8 \text{ C.H.B.}$$

Proof:

$$\frac{\$.33}{50.8} = \$.0065 \text{ Credor Cost}$$

If the plan has not been in use long enough in the plant to set up Credor Hour Bases for the various operations, the management can arbitrarily fix starting rates which will determine them.

Example.—A 39-ct. starting rate is specified for a 48-ct. base-rate job. What is the C.H.B.?

Solution:

$$\frac{\$.39}{\text{Credor Cost}} = \frac{.39}{.008} = 48.7 \text{ C.H.B.}$$

Upon this basis of establishing a C.H.B., if the starting rate is too low, the average operator will have no trouble in exceeding his base schedule, which was determined from the lower rate.

Using Credor Hour Bases for learners enables them to watch their own progress. When their productivity increases, it offers them definite possibilities of receiving larger earnings on a basis of increasing weekly starting rates.

Example.—Suppose that a new operator is hired at 36 cts. as a starting rate for a 45-ct. base-rate job that usually requires several weeks of experience for the operator to reach a 60 C. Hour. Further suppose that the operator is of the average type and therefore may receive two intermediate wage increases before he demonstrates that he is entitled to the full 45-ct. base rate for the job. The increases would work as follows:

36 cts. Must reflect 48 C.H.B. for average of one week.
39 cts. Must reflect 52 C.H.B. for average of one week.
42 cts. Must reflect 56 C.H.B. for average of one week.
45 cts. Must reflect 60 C. Hour for average of one week.

The new man is hired at 36 cts. and is expected to average 48 C.H.B. for one week. However, if during his first week he averages 52 C. Hour or more, he is entitled to the 39-ct. rate which becomes effective for his second week's work. If his second week's endeavor yields 56 C. Hour or better, he receives 42 cts. for his third week, etc. When he has finally demonstrated a 60 C. Hour for one week, he is entitled to the full 45-ct. base rate for the job.

Each week's qualifying performance should be made up of at least 85 per cent of the time spent on standards. Thus, if the factory works 40 hr. per week, the learners should reflect a progress based on at least 34 hr. on standard. Sometimes a rate to be raised is computed from an average of the final week's performance regardless of how low some of the daily C. Hours may be in that week. Other managements feel that the performances for the final qualifying week should show a minimum

of 60 C. Hour per day and not a 60 average containing one or more days below a normal status.

Plans that offer incentives to learners in a definite manner will attract new men with latent talents or abilities who are not interested in starting work in another plant where the beginner advances only through the recommendations made by the foreman. The use of a C.H.B. definitely rewards a beginner in direct ratio to his ability without disturbing direct costs. It is of especial benefit to the exceptional man who can learn his task much sooner than the average man who is hired.

If the C.H.B. principle is used, the management should issue to each foreman a notice that should be worded somewhat as outlined on the next page.

Credor Hour Bases can be granted to old employees who, by reason of their physical limitations, cannot produce 60 C. Hour. These loyal employees should not be penalized for their years of faithful service but should be rewarded by a definite process that will maintain their past earnings without injury to standard direct costs. When aged employees cannot maintain a 60 C. Hour output, they should be placed on C.H.B. schedules that are periodically adjusted downward in proportion to their diminishing productivity. The differences in earnings caused by this process should be made up to them in the form of extra pay envelopes drawn from a special fund, so that their current earnings are on a parity with the previous wages enjoyed in their more productive days. The special fund may be called a pension fund and may be built up in the same manner as money set aside for depreciation of buildings or equipment.

The majority of old employees do not want to resign in order to take advantage of a full pension allowance but prefer to remain on their jobs as long as their efforts are not being discounted by younger and perhaps unsympathetic supervisors. If the regular work of an old employee demands a high volume to preserve a balanced flow of materials and if his compliance with this necessity is not consistent with his physical condition, he should be transferred, without financial loss to himself, to an easier job where his contribution to production is made in a more leisurely fashion.

There are frequent occasions where regular operators are generally only slightly better than normal and periodically "fall

NOTICE

Credor Hour Base Data

New operators will be paid on a C.H.B. schedule nearest to the rate at which they were hired. Premium will be paid for Premium Credors earned in excess of their schedule requirement.

The following table covers the Credor Hour Bases for the various starting rates. For example, a new man is hired at 45 cts. per hour for a 54-ct. job. He is required to produce only 50 Credors per hour to be normal on the basis of his starting rate. If we assume that he actually made a 52 C. Hour, he is therefore entitled to 2 Premium Credors for every hour that he is on standard. The regular base rate is used for the value of Premium Credors earned.

Starting rates, cents	Standard Base rates, cents												
	36	39	42	45	48	51	54	57	60	63	66	69	72
	Approximate Credor Hour Base schedules												
36	60	55	51	48	45	42	40	38	36	34	33	31	30
39		60	56	52	49	46	43	41	39	37	35	34	33
42			60	56	52	49	47	44	42	40	38	36	35
45				60	56	53	50	47	45	43	41	39	37
48					60	56	53	50	48	46	44	42	40
51						60	57	53	51	49	46	44	42
54							60	57	54	51	49	47	45
57								60	57	54	52	50	47
60									60	57	54	52	50
63										60	57	55	52
66											60	57	55
69												60	57
72													60
etc.													

Maintenance of a C. Hour equal to the next higher starting rate for a minimum of 34 hr. out of the 40 hr. per week will automatically effect a raise to the next higher rate in the following week. For illustration, a new man is hired for a 66-ct. base job but is paid only 57 cts. as a starting rate. His schedule, therefore, requires only 52 Credors per hour. Assuming he actually averaged 54 C. Hours for his first week, he is automatically granted an increase to 60 cts. which becomes effective at the beginning of his second week.

Date: ____________ Signed (Superintendent)

into the red" on account of lessened output. These occasions may be partly due to improper manufacturing conditions or to the personal habits of the operators whose conduct outside of working hours is directly reflected in the volume of work produced. Since the base rates of the operators are guaranteed, they are expected to produce 60 Credors per hour or 480 Credors in 8 hr. of work. If they do not produce the total daily normal amount, the Credor differences should be paid to them and charged to an excess cost account. This account is called "Credors to equal standard" and is condensed into the legend "C.=Std."

To exemplify this legend, assume that an experienced operator on his regular 72-ct. base-rate job produced only 456 Credors in 8 hr. on standard and, therefore, was "in the red" for that particular day of subnormal performance. *Questions*:

a. What are the C. =Std.?
b. What is the cost of *a* charged to excess costs?
c. What is the operator's Credor Hour?
d. What premium money does he earn?
e. What is his total wage for the day?

Solution:

(*a*) Total min. on standard 480
Credors produced 456
24 C. =Std.

(*b*) $\frac{\$.72 \times 24}{60} = \$.29$ cost of C. =Std.

The 29 cts. is charged to direct excess costs accounts just as delays, etc., are charged to their respective accounts.

(*c*) $\frac{\text{Credors produced}}{\text{Hr. on standard}} = \frac{456}{8} = 57$ C. Hour

This 57 C. Hour would be posted in red ink on the daily production record because it is subnormal. Had this C. Hour been 60 or more, the posting would have been made in blue or black ink. The red ink postings of operators who have fallen below their customary records directs the attention of the foremen and others to the low averages. If an operator becomes a chronic offender, his base rate should be lowered to the point where his subnormal output is compensated for by a suitable C.H.B.

(*d*) Since he was subnormal, he earned no premium.

(*e*) His base rate is guaranteed, so his wage is

$$72 \text{ cts.} \times 8 \text{ hr. in factory} = \$5.76.$$

The wage paid may also be considered from this angle: The operator was supposed to produce 480 Credors per day, each of which was valued at .72/60, or \$.012; therefore, 480 × .012 = \$5.76 total wage for the day.

Continuing the above example, we shall assume that the operator repeatedly violated his base rate by producing 456 Credors each day; consequently, it was decided to place him on a Credor Hour Base. *Questions:*

a. What is the adjusted base rate?
b. What is the new C.H.B.?
c. What are the C. =Std.?
d. What is the premium earned?
e. What is the daily wage?

Solution:

(*a*) Using the actual C. Hour and the base-rate Credor Cost:

$57.0 \times \$.012 = \$.684$. Use the 66 cts. rather than 69 cts. to protect against further violation.

(*b*) Using the new rate and the base-rate Credor Cost:

$$\frac{\$.66}{.012} = 55 \text{ C.H.B.}$$

(*c*) There are no Credors to equal standard because, although the operator continues to produce a 57 C. Hour, his newly applied C.H.B. requires only 55 Credors per hour. The 57 C. Hour should be posted in green or brown ink to indicate that, although it is below normal, nevertheless it exceeds the subnormal performance which has been called for.

(*d*)

Total Credors produced	= 456
Time on standard 55 × 8 hr.	= 440 min.
Premium Credors	= 16

The value of a Premium Credor depends upon the incentive allowed by the particular plan in use. Chapter XV stated that a plan should offer an incentive between 25 and 35 per cent over the base rate. In that same chapter a problem was given in which a Premium Credor was valued at 75 per cent of the Credor Cost. For the sake of consistency, we shall apply that principle to this problem.

$$\frac{\$.72}{60} \times 75 \text{ per cent} = \$.009 \times 16 \text{ Premium Credors} = \$.14 \text{ premium}$$

(*e*)

New rate 66 cts. × 8 hr. = \$5.28 base-rate wage
.14 premium
\$5.42 total daily wage

It is noted that the new total daily wage, which includes premium money, is less than the basic daily wage previously enjoyed by the operator on his old 72-ct. base rate.

Let us further continue the two foregoing examples and assume that a new man is hired and placed on this operation upon the basis of a 48-ct. starting rate and that he was in red for his first day as follows:

$$\frac{\$.48}{.012} = 40 \text{ C.H.B.} \times 8 \text{ hr.} = 320 \text{ required Credors}$$

Assume that he produced only 312 Credors
Credors to equal standard = 8

His posting is 39 C. Hour $\left(\dfrac{312 \text{ Credors}}{8 \text{ hr. on standard}}\right)$ made in red ink because he did not equal the 40 C.H.B. that was called for, thus causing 8 Credors to be costed as excess costs at the 72-ct. base rate.

The Credors to equal standard that are allowed to an operator for one day's poor showing should not be applied against the next day's credits to adjust prior inefficiencies. For example, if an operator who is "in red" one day has a performance of over 60 on the following day, no attempt should be made to penalize the second day's showing. Each day should be considered as a separate story and costed as such.

This book makes no attempt to enter the field of cost accounting, since the various systems in use arrive at cost statements by different methods. Regardless of the cost systems in use, however, the principles of Credor Hour Bases and Credors to equal standard should be properly interpreted before their final absorption into cost statements. These interpretations are

Use regular base rate to cost all Credors that are produced.
Use regular base rate to cost all Premium Credors.
Use regular base rate to cost all Credors to equal standard.
Use regular base rate to cost all A.I.T. allowances.
Use learner's rate to cost all delays (check-out times).
Use learner's rate to cost all penalties for tardiness.
Use learner's rate to compute the basic daily wage.
Use actual hours on standard to obtain Credor-hour performance.

Problems

1. With reference to the shop notice on page 323 of this chapter, what C.H.B. is necessary for a 45-ct. starting rate assigned to an operation carrying a regular 54-ct. base rate?

2. Show the slide-rule setting for the C.H.B. where the regular base and starting rates are known.

3. Show the slide-rule setting for the starting rate where the regular base rate and C.H.B. are known.

4. Three elderly daywork operators, all of whom were engaged on the same operation, were time-studied. A C. Standard of 1.5 min. was set up for their work and a 63-ct. base rate was specified. After the application was made, it was found that the average daily production of each man was as follows:

Man No. 1 averaged 320 pieces in 8 hr. on standard.
Man No. 2 averaged 310 pieces in 8 hr. on standard.
Man No. 3 averaged 290 pieces in 8 hr. on standard.

What rates should be given to each of the three men in order to preserve Credor Costs?

5. The four-week records of a newly hired operator are as follows:

First week's performance = 51.5 C. Hour average
Second week's performance = 53.0 C. Hour average
Third week's performance = 58.8 C. Hour average
Fourth week's performance = 65.0 C. Hour average

The new man was given 63 cts. per hour as a starting rate and was advised that the job carried a regular 75-ct. base rate which would be given to him as soon as he could qualify by reaching a productive volume that reflected a minimum of 60 C. Hour average for one week. He was also told that before he reached that final base he would be entitled to one or more 3-ct.-per-hour weekly increases provided his progressing weekly Credor-hour performances did not disturb the Credor Cost of the job.

On a basis of the four-week data shown, what is the hourly rate he received for each week and during what week did he receive the final rate as promised?

6. A learner is hired in the carpenter shop and is given a schedule of 52 C.H.B. He works on standard for 8 hr. and produces a total of 36 special packing cases. Each case is covered by a 12.5-min. C. Standard. *Questions:*

a. How many Premium Credors did he earn?
b. What was his Credor-hour performance?
c. Should the posting be made in red or black ink?

7. Another learner was hired in the same carpenter shop on the same basis and given the same job as outlined in Prob. 6. This second man, although he was in the shop for 8 hr., had 30 min. of delay because of material shortage. However, while he was on standard, he made 30 cases.

a. How many Premium Credors did he earn?
b. What was his Credor-hour performance?
c. Should posting be made in red or black ink?

8. A beginner is hired at a starting rate of 42 cts. on a 51-ct. operation. He produces 280 pieces of work which carry 1.53 min. C. Std. per piece. Because of necessary repairs to his machine, he is allowed 30 min. Time Off Standard in his 8 hr. of work. Besides guaranteeing his starting rate, the plan in use allows an incentive of 75 per cent of the value of all Credors produced in excess of his C.H.B. The other 25 per cent value of the Premium Credors is set aside for a fund for the indirect workers. *Questions:*

a. What is his C.H.B.?
b. What is his Credor-hour performance?
c. What are his total earnings for the day?
d. What is the cost of the job to the company?

NOTE: The value of Premium Credors is determined from the regular base rate of the job and not from the starting rate.

9. An untrained operator is hired for a machine operation that is 90% N.W.T. and carries a 1.8-min. C. Std. per casting. The regular base rate of the job is 48 cts., but the operator is given a starting rate of 42 cts. The factory works 8 hr. per day, during which time he produced 220 castings. How many Premium Credors did he earn? What is his Credor-hour performance? How many A.I.T. minutes were charged to excess costs?

10. Referring to Prob. 9 above, another operator was hired for the same operation on a second machine. All conditions were the same except that this man produced only 190 castings in 8 hr. However, he was allowed 24 min. check-out time because of repairs made to his machine. How many Premium Credors did he earn? What is his Credor-hour performance? How many A.I.T. minutes were charged to excess costs?

Answers to Problems

1. Referring to the shop notice on page 323, at the intersection of two lines drawn, one a horizontal line extending from the 45-ct. rate in the left-hand column of starting rates and the other a vertical line extending downward from the regular 54-ct. base rate, will be found 50 C.H.B.

2. $\frac{\text{C}}{\text{D}} \Big| \frac{\text{Set base rate}}{60} \Big| \frac{\text{On starting rate}}{\text{Read C.H.B.}}$ or as follows:

$$\frac{\text{C}}{\text{D}} \Big| \frac{\text{Base rate}}{\text{Starting rate}} \Big| \frac{\text{On 60}}{\text{Read C.H.B.}}$$

3. $\frac{\text{C}}{\text{D}} \Big| \frac{\text{Base rate}}{60} \Big| \frac{\text{Read starting rate}}{\text{C.H.B.}}$ or as follows:

$$\frac{\text{C}}{\text{D}} \Big| \frac{\text{Set C.H.B.}}{60} \Big| \frac{\text{Read starting rate}}{\text{Base rate}}$$

4. Man 1: $\dfrac{320 \times 1.5 \text{ min.}}{8} = \dfrac{480}{8} = 60$ C. Hour

This man is normal and is entitled to the 63-ct. base rate as long as he does not produce less than a normal output.

Man 2: $\dfrac{310 \times 1.5 \text{ min.}}{8} = \dfrac{465}{8} = 58.1$ C. Hour

$58.1 \times .0105 = \$.61$. Call 60 cts. to observe wage scale.

Man 3: $\frac{290 \times 1.5 \text{ min.}}{8} = \frac{435}{8} = 54.4$ C. Hour

$54.4 \times .0105 = \$.571$. Call 57 cts. to observe wage scale.

5. First week $51.5 \times \$.0125$ Credor Cost $= \$.644$

He is not entitled to the increase of rate for the next week because $\$.66/.0125 = 52.8$ is the necessary minimum C. Hour.

Second week $53 \times \$.0125$ Credor Cost $= \$.663$

This week he is still on the 63-ct. starting rate but has qualified for 66-ct. rate because only 52.8 C. Hour is necessary.

Third week $58.8 \times \$.0125$ Credor Cost $= \$.735$

This week, although on the 66-ct. rate, he has qualified to jump one intermediate rate to receive 72 cts. for next week.

Fourth week 65 C. Hour exceeds a normal status

Although receiving 72 cts. this week, he will receive the regular base rate for the next week.

Fifth week 60 C. Hour or more $= \$.75$

The final 75-ct. base rate becomes effective and is paid as long as a normal status is maintained.

6.

(*a*) 36 cases × 12.5 min. C. Std. per case = 450 Credors made
52 C.H.B. × 8 hr. on standard = 416 min. on C.H.B. standard
34 Premium Credors earned

(*b*) $\frac{450}{8} = 56.3$ C. Hour

Proof:

56.3 C. Hour made
52.0 C.H.B.
4.3 × 8 hr. on standard = 34 Premium Credors earned

(*c*) Posted in black, green, or brown ink.

7.

(*a*) 8 hr. − ½ hr. = 7½ × 52 C.H.B. = 390 min. C.H.B. standard
30 cases × 12.5 min. C. Std. per case = 375 Credors made
15 C. = Std.

(*b*) $\frac{375}{7.5} = 50$ C. Hour

Proof:

52 C. Hour paid
50 Credors earned
2 × 7.5 hr. = 15 Credors to equal standard

(*c*) Posted in red ink.

8.

(a) $$\frac{\$.42 \times 60}{.51} \text{ or } \frac{\$.42}{.0085} = 49.4 \text{ C.H.B.}$$

(b) $$\frac{280 \times 1.53 \text{ min.}}{480 - 30} = \frac{428 \text{ Credors}}{7.5 \text{ hr.}} = 57.1 \text{ C. Hour}$$

(c) Work made during 7.5 hr. on standard = 428 Credors
371 min. C.H.B. standard
57 Premium Credors

His basic wage for the day .42 × 8 hr. = \$3 .36

His premium money $\frac{.51}{60}$ × 75 per cent × 57 Premium Credors = .36
Total earnings for the day = \$3 .72

(d) Fund: $\frac{.51}{60}$ × 25 per cent × 57 Premium Credors = \$ .12
Total wage paid = \$3 .72
Total cost = \$3 .84

Proof:

280 × 1.53 × .0085 = \$3.63
30 min. delay × .007 = .21
Total cost = \$3.84

9.

His required performance is $\frac{\$.42}{.008}$ = 52.5 C. H. B.
His time on standard 52.5 × 8 hr. = 420 min. on C.H.B. standard
The allowed working time is 420 min. × 90% N.W.T. = 378 min.
Castings produced 220 × 1.8 min. C. Std. = 396 Credors made
Effective time on C.H.B. standard = 378 min.
Premium Credors earned = 18

$$\frac{396 \text{ Credors}}{8 \text{ hr.} \times 90\% \text{ N.W.T.}} = \frac{396}{7.2} = 55 \text{ C. Hour performance}$$

420 = min. on C.H.B. standard
378 = effective working min.
42 = min. of A.I.T.

10. His required performance is 52.5 C.H.B. He had 24 min. or .4 hr credit for machine repairs.

(8 hr. – .4 hr.) × 52.5 = 399 min. on C.H.B. standard
The allowed working time = 399 × 90% N.W.T. = 359 min.
190 castings made @ 1.8 min. C. Std. per casting = 342 Credors
No premium earned—instead, the C. =Std. = 17 Credors

$$\frac{342 \text{ Credors}}{(8 \text{ hr.} - .4 \text{ hr.}) \times 90\% \text{ N.W.T.}} = \frac{342}{6.84} = 50 \text{ C. Hour}$$

399 = min. on C.H.B. Std.
359 = Effective working min.
40 = min. of A.I.T.

Chapter XVIII

In its treatment of the checking card, Chap. XVIII incorporates combination uses of many of the principles outlined in the previous pages. Therefore, this chapter not only is another review of those principles but also explains the correct methods of posting and converting to costs the various items listed each day on the card.

CHAPTER XVIII

THE CHECKING CARD

A checking card, originated by the departmental factory clerk, is the medium used to record the daily performance of each operator. The clerk makes out a new card every morning for each operator. On it is recorded the operator's production of one or more different jobs, all allowed check-out times, and other required data necessary for the daily figuration done by the cost-office clerks.

The design of a checking card should be considered for its flexibility in meeting all manufacturing conditions in the plant. If the conditions prove to be too complex, it may perhaps be advisable to employ more than one design in order to simplify the work for each department.

Figure 23 on the next page shows the design of a checking card that is flexible enough to meet the general manufacturing conditions encountered. The design shown applies to a premium plan but may be modified to suit piecework plans that allow time credits to operators for delays beyond their control. The checking cards, 5½ by 8½ in. in size, are made up in pad form with about 100 sheets per pad and are printed in black on a fairly cheap grade of white paper. A description of the various legends follows in the next several paragraphs.

Each morning the factory clerk fills out the top section of the card with the operator's name and clock number, the department name or number, and the date. As stated, only one card is required per operator regardless of how many jobs of different standards or base rates the operator works on during the day. The cards are turned in to the cost office on the following morning. Before doing so, however, the shop clerk goes to the rack that contains the operators' clock cards and enters the time postings of the previous day in the windows specified in the upper right-hand corner of each card. This process is called "reconciling with the clock card." The latter, of course, is the official

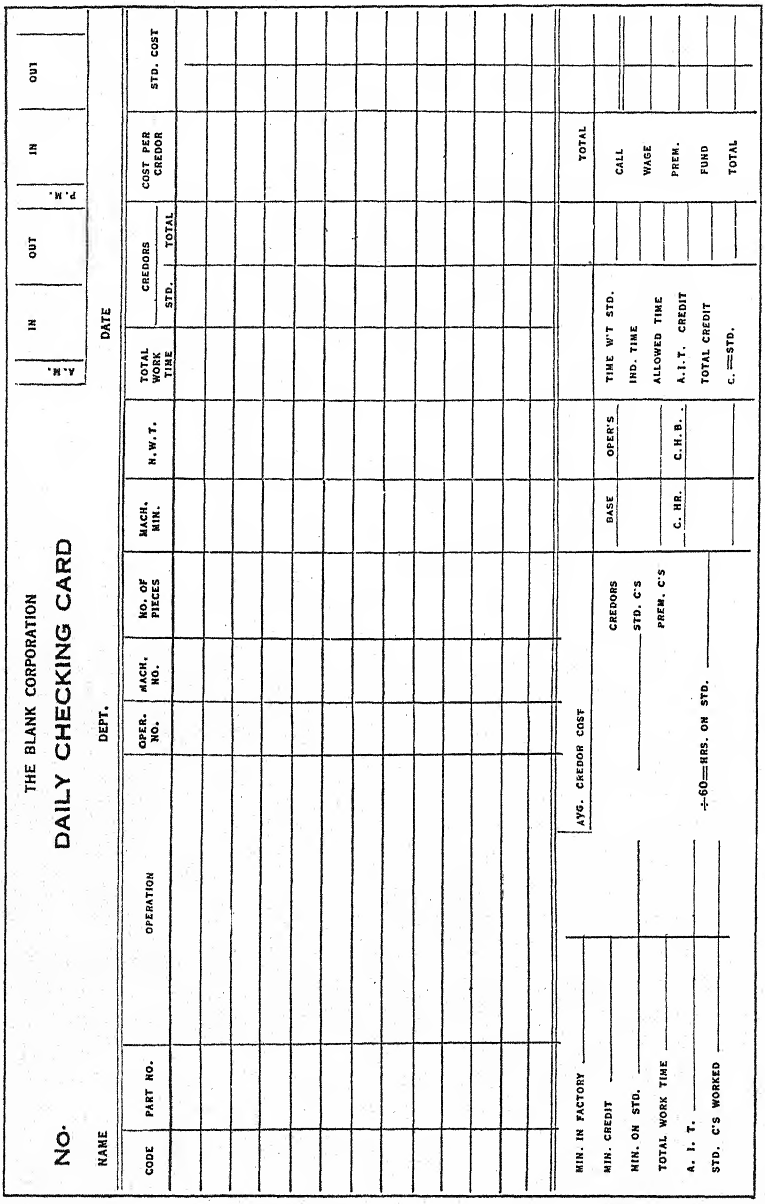


FIG. 23.—Style of checking card recommended.

data used to make up the basic wage, but the checking card must be in agreement with the clock card so that tardiness penalties are recognized in the cost figurations. Checking cards are turned in for absentees and for the dayworkers who are not as yet applied to the plan.

With reference to tardiness, many plants impose penalties on the operators whose clock cards show late arrivals. To facilitate figuration, the penalties are imposed on the basis of tenths of hours, thus:

TARDINESS PENALTIES

1 to 6 min. late, penalize $\frac{1}{10}$ hr.
7 to 12 min. late, penalize $\frac{2}{10}$ hr.
13 to 18 min. late, penalize $\frac{3}{10}$ hr.
19 to 24 min. late, penalize $\frac{4}{10}$ hr.
25 to 30 min. late, penalize $\frac{5}{10}$ hr.
etc.

The factory clerk is given a copy of the tardiness penalties so that he may mark the net working time elsewhere on the card.

Code.—This column is generally filled in by the cost clerk who indicates the account numbers to which the data are finally costed.

Part Number.—The shop clerk enters the one or more part numbers of the jobs worked on during the day. This information is obtained from blueprints, job tickets, or instruction sheets.

Operation.—This space receives a brief description of the operations, such as drilling, assembly, lathe, bench, etc. It also receives check-out data and the times for them:

Wait for material	4 min.	Sweep floor	19 min.
Fix belt	6 min.	Await foreman	7 min.
Repair machine	21 min.	Daywork	183 min.
First aid	25 min.	etc.	

If the check-out times are numerous, the back of the card can be used to record the overflow of data.

Operation Number.—This information is correlative with Part number and Operation columns.

Machine Number.—If Credor Standards have been built for old and new machines, all of which are used for the same operation, the shop clerk, by his entry of the machine numbers in this column, identifies the operation so that the cost clerk can select the proper standards without possibility of error.

Number of Pieces.—The shop clerk enters the total production of pieces, pounds, feet, yards, etc., for the day.

Machine Minutes.—This column is used only in connection with P.M.T. operations that have normal working times of less than 100 per cent. The net daily time per machine is shown. For example, if the machine had one or more allowed delays during the day and if the total delay time amounted to 15 min., the shop clerk's entry in the column is 465 min. (based on an 8-hr. day).

If the operator is running a combination of the same or different types of machines and one or more of them are allowed time credits, the actual amount of down time is granted only to the machine affected and not prorated over all machines in the combination. To amplify this statement, we shall assume that an operator is running four machines. During the day, each of them is given a different time allowance. The shop clerk credits them as follows:

Part number	Operation	Operation number	Machine number	Number of pieces	Machine minutes
125	Belt breakage, 8 min.	5	100		472
125	Wait for material, 17 min.	5	101		463
721	Machine repairs, 32 min.	10	106		448
350	Wait for material, 3 min.	2	205		477

Normal Working Time.—The cost clerk posts this column by entering the N.W.T. percentage that is specified by the C. Standard data.

Total Work Time.—This posting, made by the cost clerk, is the product found by multiplying the Machine minutes entries by the N.W.T. percentages. If we continue the above example of the four-machine combination and prescribe normal working percentages, the working times allowed to the operator for each machine are as shown in the table on page 337.

The difference, found by subtracting the 450-min. working time total from the working minutes in the day, yields the minutes of A.I.T. unless the operator has received personal credits. These are allowed when all four machines are simultaneously

delayed for such reasons as stoppage of power, no material for all four machines, etc.

Machine No.	Machine minutes	Per cent N.W.T.	Total work time, minutes
100	472	30	142
101	463	22	102
106	448	16	72
205	477	28	134
			450

Credors

Standard, Total.—These two columns are computed by the cost clerk. The Standard column receives the C. Standard specified for the operation which, when multiplied by the quantity in the Number of Pieces column, indicates the total Credors made. It is not advisable to show fractional Credors.

Cost per Credor.—The cost clerk determines the Credor Cost from the base rate of each operation and posts it in this column.

Standard Cost.—This column is the product found by multiplying the total Credors by their respective Credor Costs. It is advisable for the cost clerk to carry the figuration to three decimal places.

Minutes in Factory.—The factory or cost clerk scans the clock readings in the upper right-hand corner and posts the minutes of shop time credited to the operator. If the factory works 8 hr. per day and if the operator was 14 min. late, the posting becomes 480 min. $-$ $\frac{3}{10}$ hr. $=$ 462 min.

Minutes Credit.—The factory or cost clerk enters the total minutes of allowances for check-out times. Delays of 3 min. or more are allowed to manual, H.M.T., and P.M.T. operations. When the latter is on a multiple basis, only those delays are allowed which are sustained by the operator when all the machines are down simultaneously. In the operation of a combination of machines, if one of the group is in operation, the operator is receiving A.I.T. for the others while they are stopped.

Minutes on Standard.—The cost clerk posts here the difference found by subtracting the Min. Credit from Min. in Factory. The posting of the difference is also repeated on the right-hand end of the same line outside of the nearest vertical line.

Total Work Time.—This space is used only for P.M.T. operations where the N.W.T. is less than 100 per cent. When this space is used, the data are the total minutes that are found in the vertical Total Work Time column above, which is repeated in this space for ease of figuration on the part of the cost clerk.

Available Idle Time.—The cost clerk subtracts the Total Work Time from the Min. on Std. time and posts the difference on that part of the A.I.T. line which is outside of the nearest vertical line.

Standard Credors Worked.—This posting is the difference found by subtracting the A.I.T. minutes from Min. on Std. The difference becomes the basis for the figuration of Credor-hour performance, as indicated by "÷ 60 = Hrs. on Std." legend.

Average Credor Cost.—This will be explained later in the chapter.

Credors.—This space receives the total Credors as indicated at the foot of the vertical Credor Total Column above.

Standard Credors.—This is a transferred posting as indicated in the lower left-hand corner under Std. Credors Worked.

Premium Credors.—This is the difference between the two postings immediately above.

Hours on Standard.—This is obtained by dividing the Standard Credors Worked column by 60, as indicated by the formula that connects these two legends.

NOTE: If the operator is assigned a C.H.B. schedule, the figure usually specified in the Standard Credors Worked window is not used. Instead, the actual hours on standard or the effective hours on standard are used.

Base: Cost clerk enters the regular base rate.

Operator's: Cost clerk enters the learner's rate when used.

C. Hour: Cost clerk enters the Credor-hour performance.

C.H.B.: Cost clerk enters the C.H.B. when used.

With reference to the Operator's window, this space is also used to show possible guaranteed personal hourly rates which may be higher than the regular job base rate.

Time Without Standard.—This space and the five that are below it are used by the cost clerk in gathering his data preliminary to reflecting them in cost statements.

If the T.S.M. has made a partial application, not all of the operations are covered by standards. In this event, the oper-

ator may be required to work on jobs on a day-work or time-without-standard basis. It is in this latter space that the day-work minutes are entered.

Indirect Time.—All accountants do not interpret check-out times in the same way. Some feel that, when an operator checks out to sweep floors, clean machines, move materials, etc., he automatically becomes an indirect worker for the duration of such tasks. Any total check-out minutes that are interpreted as indirect costs are posted to this space.

Allowed Time.—This receives the total check-out minutes that are considered as direct costs.

A.I.T. Credit.—This receives the total minutes of available idle time that is elsewhere found on the checking card.

Total Credit.—This is the sum of minutes found by adding the four columns immediately above.

Credors to Equal Standard.—This space receives its data from the lower center section which is used to determine Premium Credors. If the operator has demonstrated a subnormal performance, this latter section shows Credors to equal standard instead of Premium Credors.

Call
Wage
Premium
Fund
Total

These five headings are the last to appear in the lower right-hand corner and are explained as follows:

Call.—This total is the modified sum of the total on the line above, which is raised or lowered less than 1 ct. to be in agreement with the last Total in the lower right-hand corner.

Wage.—This receives the basic wage computed from the clock postings in the upper right-hand corner. The wage is determined:

For a learner, use the starting or intermediate rate.

For a regular operator, use the official base rate.

For an operator who has a high guaranteed personal rate, use his personal rate if it exceeds the "Call" total, the difference being entered above it and the "Call" adjusted to be in agreement with the Wage space. Show to two places to right of decimal point.

Premium.—This shows the premium money earned. This sum, when added to a learner's or a regular operator's basic

wage, will indicate his total wage earned for the day. Show to two places to right of decimal point.

Fund.—If the wage-incentive plan offers and sets aside for indirect workers premium money which is created by the direct worker, that portion of it created by the direct worker is posted herein.

Total.—This is the sum of Wage, Premium, and Fund. If the latter is not used, the Total is the sum of the first two legends.

One of the virtues of this style of checking card is that the cost clerk cannot pass it as completed until it is cost-balanced. If it does not balance, it is obvious that an error was made or that all the proper items were not embodied in the figuration.

When the T.S.M. analyzes a job preparatory to establishing operational elements, he considers all details that have a direct or indirect bearing on the time study to be taken. One of the details to be given consideration is the question of applying the checking card to each operation. Some jobs will readily lend themselves to simple methods of keeping track of the work produced, delay times, etc., while others will tax the ingenuity of the T.S.M. to find simple foolproof means of determining accurate checking-card data.

The type of straight-line production that is immediately absorbed in the production flow of materials is a comparatively simple checking-card problem. The fact that this kind of work is not building up an uneven surplus of materials in the department but is constantly moving in a uniform volume allows the shop clerk easily to keep track of the work produced per operator. The differences between raw materials that are started and finished work that is delivered signalize the uncompleted work in process, the parts that are spoiled or made up for repair orders, or the stockroom demands for which certain operators must receive production credits in addition to those allowed for the finished units counted at the end of the line.

The actual time spent by a clerk in counting large amounts of small-sized work produced by various machines is sometimes such a costly item that it is cheaper to accept the operator's statements of his daily production than it is to count the completed work. The majority of operators are honest and will truthfully report their performances. The statements of other operators can often be accepted and occasionally verified by

actual count. In other words, "It is not wise to spend a dollar to prevent a 5-ct. error."

Machines that are equipped with counters or other recording devices not only show actual output but conserve much of the clerk's time. Special weighing scales are great time savers when determining the amount of small pieces manufactured. Special trays or light work trucks that contain a fixed amount of holes or pegs quickly tell the total work on them by the number of work spaces that are left unfilled.

Production is recorded by the clerk at the time of its completion regardless of the period of the day. In the case of continuous or automatic machines, the finished work is recorded shortly before the final stopping whistle. This brief space of times does not always allow the clerk sufficient time to obtain all performance records properly without staying on the job after the men have stopped work. To facilitate the collection of data for checking cards, it is often advisable to close officially each day's output from 30 min. to 1 hr. before the final stopping whistle. This will allow the clerk ample time to obtain and record his data without having to work overtime.

The selection of clerks, as of operators, is outside the province of a T.S.M.'s duties. However, he is vitally interested in having proper individuals assigned to checking cards and, if he finds that a clerk who has been selected is not capable of handling the work properly, he should never hesitate to recommend a change in clerkship. Space need not be taken to outline the characteristics that are required for a clerk beyond saying that chief among his qualities must be honesty, accuracy, and alertness. A clerk should be centrally located so that he can do full justice to his job. He should not be requested to report infractions of discipline, idle rumors, or "shop politics" that are current in every plant. He is, however, expected to follow impartially and honestly the instructions given to him.

The T.S.M. instructs each factory clerk regarding the checking-card requirements of every applied operation. The clerk is told about the 3-min. delay clause and is advised concerning delays which may be requested by operators but which should not be allowed. For example, some operators will endeavor to obtain check-out times for getting drinks of water or allowances for discussing personal matters with other workers and for doing

THE BLANK CORPORATION

No. 15-097 DAILY CHECKING CARD

	IN	OUT		IN	OUT
A.M.	7:50	12:01	P.M.	12:55	5:05

NAME John Doe DEPT. 3G DATE June 5, 193–.

CODE	PART NO.	OPERATION	OPER. NO.	MACH. NO.	NO. OF PIECES	MACH. MIN.	N.W.T.	TOTAL WORK TIME	CREDORS STD.	CREDORS TOTAL	COST PER CREDOR	STD. COST
	189	Grinder	14	G91	135				.6	81	$.008	648
	195	"	3	"	663				.28	186	"	1 488
	501	"	7	"	390				.5	195	"	1 560
		Daywork 120′									"	960
		Wait for set up 5′									"	040
		" " material 10′									"	080
		" " inspection 5′									"	040
		Sweep around mach. 4′									"	032
		144′										
						—	—	—	—	462	TOTAL	4 848

MIN. IN FACTORY	480
MIN. CREDIT	144
MIN. ON STD.	336
TOTAL WORK TIME	—
A. I. T.	—
STD C'S WORKED	336

AVG. CREDOR COST

462	CREDORS
336	STD. C'S
126	PREM. C'S

÷60=HRS. ON STD. 5.6

BASE	OPER'S
48	
C. HR.	C.H.B.
82.5	

TIME W'T STD.	120
IND. TIME	9
ALLOWED TIME	15
A.I.T. CREDIT	—
TOTAL CREDIT	144
C. =STD.	—

CALL	4 85
WAGE	3 84
PREM.	76
FUND	25
TOTAL	4 85

FIG. 24.—Showing figuration of three different jobs and check-out times allowed to the one operator.

many other things that are taken care of in the standards or that are not permissible. Both the foreman and his clerk are interested in keeping check-out times as low as possible, because they are (aside from day-work times) charged to excess costs. Each clerk uses his wrist watch or the clock on the wall to record check-out times.

Cost clerks are requested to advise the T.S.M. or foreman regarding abnormal Credor-hour performances, to watch certain operator C. Hours, and to report any odd circumstances attending operations on standard that may influence quality or costs.

Where an operator works during the day on one or more jobs that carry different C. Standards, it is not necessary to observe the starting and finishing time of each job. As long as the operator is on standard, he is, in the eyes of the cost department, producing Credors that may, or may not, be translated into terms of costs per piece. If an operator is producing above his normal base, he is producing work at a direct standard cost. If actual direct costs are higher than standard costs, the differences are due to excesses that are the only items on which the clerk is required to report in-and-out times. The exception to this rule of not recording the starting and stopping times of more than one standardized job handled during the day occurs in the case of a group of A.I.T. operations. The reader should refresh his memory on this by rereading pages 220 and 221 in Chap. XII, which offer an example that covers this deviation from the rule. Of course, if the department is only partially applied, the in-and-out times of operations carrying standards must be observed and recorded when these are interrupted by day-work or time-without-standard jobs.

Figure 24 shows a sample checking card made out for a 48-ct. grinder hand who, during 8 hr. in the shop, had 144 min. time off standard for the several reasons indicated. His 82.5 C. Hour, based on 5.6 hr. on standard, resulted in 126 Premium Credors, each of which was valued at 75 per cent of the Credor Cost. Thus, the premium money was 76 cts., which, when added to \$3.84, amounted to a total wage of \$4.60 for his day's performance. Had there been no day-work or check-out times, the operator's 82.5 C. Hour might have accrued from 8 hr. on standard, in which event he would have earned \$4.92 for the day.

Note that the only times which were recorded were day-work and other check-out times.

Note also that the eight slide-rule cost extensions yielded a trial total of only 2/10ths of 1 ct. below the last $4.85 total. Premium is specified in even and not fractional cents. The small adjustment caused by doing this may cause the final total to disagree with the one above by less than 1 ct. The compensating or "washout" figure that is modified to cause the balance is the Fund, which may require raising or lowering by not more than 1 ct.

In Chap. XV, on page 291, a 4-hr. time interval was explained, during which the operator kept his own rate when he was transferred to another job that carried a different rate. This rule must sometimes be changed to take care of certain operators who continually work on different base-rated jobs during the day and, therefore, must immediately take the base rates of the jobs to which they are assigned. In cases of this kind, the operator may have a personal hourly rate but it is seldom used. Instead, his basic pay and premium are computed from the Average Credor Cost, which is the remaining space on the sample checking card to be explained.

In explanation of Average Credor Cost, the checking card as outlined in Fig. 24 is altered in accordance with Fig. 25 to show the figuration of the grinding operation where the three jobs are carrying different base rates. It is not likely that these grinding jobs would actually have different rates, but that assumption is maintained to expand the previous checking-card problem.

With reference to Fig. 25, the cost clerk made the standard-cost extensions by multiplying the three jobs by their respective Credor Costs. The total of the three extensions is $3.984 which, when divided by the 462 Credors that were made, results in a quotient of $.00862, which is the Average Credor Cost. This figuration is usually made on the back of the checking card. After the Average Credor Cost has been obtained and posted in its space, the check-out times are computed as shown. These extensions, when added to the Credor Costs, resulted in a $5.225 total. Since the operator has no personal rate, his basic pay is the product of the Average Credor Cost and his minutes in the factory or $.00862 × 480 = $4.14. The value of the Premium Credors in this case is predicated on 75 per cent of the Average Credor Cost. Note that the trial total of $5.225

THE BLANK CORPORATION

No. 15-097 DAILY CHECKING CARD

	IN	OUT		IN	OUT
A.M.	7:50	12:01	P.M.	12:55	5:05

NAME JOHN DOE DEPT. 39 DATE JUNE 5, 193–.

CODE	PART NO.	OPERATION	OPER. NO.	MACH. NO.	NO. OF PIECES	MACH. MIN.	N.W.T.	TOTAL WORK TIME	CREDORS STD.	CREDORS TOTAL	COST PER CREDOR	STD. COST
	189	Grinder 48¢	14	991	135				.6	81	.008	648
	195	" 51¢	3	"	663				.28	186	.0085	1 581
	501	" 54¢	7	"	390				.5	195	.009	1 755
										462		3 984
		Daywork 120'									.00862	1 034
		Wait for set up 5'									"	043
		" " material 10'									"	086
		" " inspection 5'									"	043
		Sweep around mach. 4'									"	035
		144'										
		$\frac{\$3.984}{462} = \$.00862$ Avg. C. Cost										

MIN. IN FACTORY	480	
MIN. CREDIT	144	
MIN. ON STD	336	
TOTAL WORK TIME		
A. I. T		
STD. C'S WORKED		336

AVG. CREDOR COST .00862

462	CREDORS
336	STD C'S
126	PREM C'S

÷60=HRS ON STD 5.6

DASE	OPER'S
C HR	C.H.B
82.5	

		TOTAL	5	225
TIME W'T STD.	120	CALL	5	23
IND TIME	9	WAGE	4	14
ALLOWED TIME	15	PREM		82
A.I.T CREDIT	—	FUND		27
TOTAL CREDIT	144	TOTAL	5	23
r =STD.	—			

FIG. 25.—Use of Average Credor Cost principle.

THE BLANK CORPORATION

DAILY CHECKING CARD

No. 15-097

NAME JOHN DOE DEPT. 39 DATE JUNE 5, 193—.

A.M. IN	A.M. OUT	P.M. IN	P.M. OUT
7:50	12:01	12:55	5:05

CODE	PART NO.	OPERATION		OPER. NO.	MACH. NO.	NO. OF PIECES	MACH. MIN.	N.W.T	TOTAL WORK TIME	CREDORS STD.	CREDORS TOTAL	COST PER CREDOR	STD COST	
	189	Grinder	48¢	14	G91	135				.6	81	.008		648
	195	"	51¢	3	"	663				.28	186	.0085	1	581
	501	"	54¢	7	"	390				.5	195	.009	1	755
		Daywork	120′								120	.008		960
		Wait for set up	5′								5	"		040
		" " material	10′								10	"		080
		" " inspection	5′								5	"		040
		Sweep around mach.	4′								4	"		032
			144′											
		$\frac{5.136}{606}$ = \$.00848												

MIN. IN FACTORY	480	AVG. CREDOR COST	.00848		606
MIN. CREDIT	144	CREDORS	462	TIME W'T STD.	120
MIN. ON STD.	336	STD. C'S	336	IND TIME	9
TOTAL WORK TIME		PREM C'S	126	ALLOWED TIME	15
A. I. T.				A I.T CREDIT	—
STD. C'S WORKED	336	÷60=HRS ON STD	5.6	TOTAL CREDIT	144
				C =STD	—

BASE	OPER'S
	48
C HR.	**C.H B**
82.5	

TOTAL	5	136
CALL	5	14
WAGE	4	07
PREM		80
FUND		27
TOTAL	5	14

FIG. 26.—Expanded use of Average Credor Cost principle.

was raised ½ ct. to be in agreement with the last total on the card.

Figures 24 and 25 are again used to exemplify the condition where an operator works on the three grinding jobs and has a personal rate of 48 cts. per hour, as indicated in Fig. 26. Note that his check-out minutes are considered as Credors and added to the regular ones to obtain the $.00848 Average Credor Cost. No further comment is necessary on this last example.

After the cost clerk has completed all the checking cards for a department, the operators are advised of their previous day's performances by means of a Daily Posting Sheet which is displayed on the departmental bulletin board. If the department is large, several of the daily posting sheets may be required in order to show all the operator data. The sheets are usually posted in the department about half an hour before the final whistle and collected after all have seen their previous day's performances. Each week new sheets are prepared for the department. The old sheets are filed and frequently are used for reference when the trend of some of the operators is being watched. A daily posting sheet is about 14 by 18 in. in size and contains 15 spaces, each of which shows the data for one operator. Each space contains information as follows:

No.________ C. Hour Previous Week________
Name

	Plant Hours	Hr. on Std.	Total Credors	Prem. Credors	Credor Hour	Prem.	Base Pay	Total
Mon.								
Tues.								
Wed.								
Thurs.								
Fri.								
Sat.								
Total								

Deductions for bad work ________
Week's earnings ________
Allowance ________
Total ________
Deductions ________
Net pay ________

Inspectors and foremen should not only take an active interest in the checking cards but should digest each daily posting sheet because it tells a very significant story. Inspectors are interested in watching the C. Hours of certain operators because a C. Hour can often be used as a gauge for quality. Knowing the usual energy capacity of each operator and his resultant work, the inspector is alert to abnormally high Credor-hour performances, because this often signalizes that quality is being impaired.

If the foreman watches checking cards and Daily Posting Sheets, he can keep check-out times at a minimum by anticipating bad working, bad material, or bad equipment conditions. He can have machine and line-shaft belts periodically inspected and perhaps repaired during the noon hour, thus preventing check-out times. If the floor sweeper or chip man cause appreciable delays to the direct workers, this work can be done before or after regular working hours. Staggered hours can be prescribed for certain setup men, repairmen, inspectors, and others whose work can be done between regular plant hours and thus prevent many check-out times.

There are operations performed on machines of such type that there should be little variation in the volume of production each day, and therefore should show stabilized C. Hours. If they do not, it is a sign that the operation has been changed. An instance of this is cited in the gear department of a truck plant. Several gear shapers were time-studied whose P.M.T. ran over 40 min., whereas the External work per cycle was less than 1 min. After the application, these machines showed even Credor-hour performances but later on the posting sheets showed higher Credor-hour levels for the same work. It was finally discovered that the operator had purchased some adhesive tape and wrapped it around the face of the feed pulley on each gear shaper, thus increasing the diameters of the pulleys which shortened the machine cycles. The machines had been repeatedly checked for speeds and feeds, because the T.S.M. knew the C. Hours were abnormal for this particular gear operation.

Checking cards, covering machine operations, often show high C. Hours because the operators increase the feeds or speeds over those which had been established as standard. Some machines have such convenient quick-change gear levers that feeds or speeds can be quickly lowered to the official ones upon

the approach of the T.S.M. or other plant officials. No matter how high the standard feeds or speeds may be set for consistent performance, there are operators who will speed up the cutting action of a machine and then, ironically enough, complain that the desired accuracy or finish cannot be produced by reason of overworked tools. The T.S.M. by his knowledge of the operator, the material, and the machine can often tell from the C. Hour appearing on the checking card or posting sheet whether the C. Standards are being violated by improper manufacturing practices.

Questions

1. In a 6-hr. per day plant which imposes tardiness penalties the same as those shown on page 335 in this chapter, how many minutes in the shop would be credited to an operator whose clock card indicates that he is 8 min. late?

2. If an operator is assigned more than one machine and is subject to A.I.T. allowances, when is he allowed personal credits?

3. Is it necessary to record the in-and-out times of each operation that carries a C. Standard?

4. With reference to the style of checking card shown in Fig. 23, what is one of the main virtues of the design?

5. On page 343 in this chapter, it was stated that, if the operator's 82.5 C. Hour accrued from 8 hr. on standard, he would have earned a total of $4.92 for his daily wage. Show the figuration for this.

Problems

NOTE: The five problems that follow were selected to show the possibilities of handling unusual combinations of circumstances. When solving these problems, the reader must recognize all items and include them for figuration in the body of the card. All items must be costed by means of the proper cost value as given in the list of interpretations on page 326 in Chap. XVII. In each case the factory works 8 hr. per day. All Premium Credors earned are valued at 75 per cent of the Credor Cost; the other 25 per cent are set aside for the fund.

6. John Doe is hired at a starting rate of 42 cts. per hour for a regular 48-ct. machine job which carries a 90 % N.W.T. Using Duplicate Fig. 27, Prob. 6, complete the figuration of the card. See Fig. 27 for rest of data.

7. Richard Doe is hired for the same operation as in Prob. 6 above. Because of necessary repairs to his machine, he was allowed 24 min. check-out time. Complete the figuration of the card shown in Fig. 28 using duplicate supplied for Prob. 7.

8. On account of a rush shop order, the foreman transferred Thomas Doe, who had a personal rate of 45 cts., to a 30-ct. job. Doe was told that the 4-hr. clause would be waived and that he would be guaranteed his 45-ct. rate regardless of his C. Hour. Figure 29 shows his performance for the day.

(*Continued on page* 360)

THE BLANK CORPORATION

DAILY CHECKING CARD

No. 150

NAME JOHN DOE DEPT. MACHINE DATE JAN. 12, 193—

	IN	OUT		IN	OUT
A.M.	8:00	12:00	P.M.	1:00	5:00

CODE	PART NO.	OPERATION	OPER. NO.	MACH. NO.	NO. OF PIECES	MACH. MIN.	N.W.T.	TOTAL WORK TIME	CREDORS STD.	CREDORS TOTAL	COST PER CREDOR	STD. COST
	3M19	Turret lathe	1	330	220		90%		1.8			

MIN. IN FACTORY ____

MIN. CREDIT ____

MIN. ON STD. ____

TOTAL WORK TIME ____

A. I. T ____

STD C'S WORKED ____

AVG. CREDOR COST

CREDORS

____ STD. C'S

PREM. C'S

÷60=HRS. ON STD. ____

BASE	OPER'S
48	42
C. HR.	C.H.B.

TIME W'T STD.

IND TIME

ALLOWED TIME

A.I.T. CREDIT

TOTAL CREDIT

C. =STD.

TOTAL

CALL

WAGE

PREM

FUND

TOTAL

FIG. 27.—Unfinished checking card relating to Prob. 6. Use the duplicate for figuration.

THE BLANK CORPORATION

DAILY CHECKING CARD

No. 150

NAME JOHN DOE DEPT. MACHINE

	A.M. IN	A.M. OUT	P.M. IN	P.M. OUT
	8:00	12:00	1:00	5:00

DATE JAN. 12, 193—

CODE	PART NO.	OPERATION	OPER. NO.	MACH. NO.	NO. OF PIECES	MACH. MIN.	H.W.T.	TOTAL WORK TIME	CREDORS STD.	CREDORS TOTAL	COST PER CREDOR	STD. COST
	3M19	Turret lathe	1	330	220		90%		1.8			

MIN. IN FACTORY ______

MIN. CREDIT ______

MIN. ON STD. ______

TOTAL WORK TIME ______

A. I. T ______

STD C'S WORKED ______

AVG. CREDOR COST

CREDORS

______ STD. C'S

PREM. C'S

÷60=HRS. ON STD. ______

BASE	OPER'S
48	42
C. HR.	C.H.B.

TIME W'T STD.

IND TIME

ALLOWED TIME

A.I.T. CREDIT

TOTAL CREDIT

C. =STD.

TOTAL

CALL

WAGE

PREM

FUND

TOTAL

Duplicate Fig. 27.—To be used by the reader for the figuration of Prob. 6.

THE BLANK CORPORATION

DAILY CHECKING CARD

NO. 151

NAME RICHARD DOE   DEPT. MACHINE   DATE JAN. 12, 193–.

	IN	OUT		IN	OUT
A.M.	8:00	12:00	P.M.	1:00	5:00

CODE	PART NO.	OPERATION	OPER. NO.	MACH. NO.	NO. OF PIECES	MACH. MIN.	N.W.T.	TOTAL WORK TIME	CREDORS STD.	CREDORS TOTAL	COST PER CREDOR	STD. COST
	3M19	Turret lathe	1	331	190		90%		1.8			
		Repair machine 24'										

MIN IN FACTORY ______
MIN. CREDIT ______
MIN. ON STD ______
TOTAL WORK TIME ______
A. I. T. ______
STD, C'S WORKED ______

AVG CREDOR COST

CREDORS
______ STD C S
PREM C S

÷60=HRS. ON STD ______

BASE	OPER'S
.48	.42
C. HR.	C.H.B

TIME W'T STD. ______
IND. TIME ______
ALLOWED TIME ______
A.I.T. CREDIT ______
TOTAL CREDIT ______
C =STD. ______

TOTAL
CALL
WAGE
PREM
FUND
TOTAL

FIG. 28.—Unfinished checking card relating to Prob. 7. Use the duplicate for figuration.

THE BLANK CORPORATION

DAILY CHECKING CARD

No. 151

NAME Richard Doe DEPT. Machine DATE Jan. 12, 193—.

	IN	OUT
A.M.	8:00	12:00
P.M.	1:00	5:00

CODE	PART NO.	OPERATION	OPER. NO.	MACH. NO.	NO. OF PIECES	MACH. MIN.	N.W.T.	TOTAL WORK TIME	CREDORS STD.	CREDORS TOTAL	COST PER CREDOR	STD. COST
	3M19	Turret lathe	1	331	190		90%		1.8			
		Repair machine 24'										

MIN IN FACTORY ______

MIN. CREDIT ______

MIN. ON STD ______

TOTAL WORK TIME ______

A. I. T. ______

STD, C'S WORKED ______

AVG CREDOR COST

CREDORS

______ STD. C'S

PREM. C S

÷60=HRS. ON STD ______

BASE	OPER'S
48	42
C. HR.	C.H.B

TIME W'T STD. ______

IND. TIME ______

ALLOWED TIME ______

A.I.T. CREDIT ______

TOTAL CREDIT ______

C =STD. ______

TOTAL

CALL ______

WAGE ______

PREM ______

FUND ______

TOTAL ______

Duplicate Fig. 28.—To be used by the reader for the figuration of Prob. 7.

THE BLANK CORPORATION

DAILY CHECKING CARD

NO. 152

NAME THOMAS DOE DEPT. MACHINE DATE JAN. 12, 193—.

	IN	OUT		IN	OUT
A.M.	8:00	12:00	P.M.	1:00	5:00

CODE	PART NO.	OPERATION	OPER. NO.	MACH. NO.	NO. OF PIECES	MACH. MIN.	N.W.T.	TOTAL WORK TIME	CREDORS STD.	CREDORS TOTAL	COST PER CREDOR	STD. COST
	147	Bench	4	—	322				2.00			
		Wait for foreman 10'									.005	
		Maintenance 5'									.005	

MIN. IN FACTORY ——

MIN. CREDIT ——

MIN. ON STD. ——

TOTAL WORK TIME ——

A. I. T. ——

STD. C'S WORKED ——

AVG. CREDOR COST

CREDORS

—— STD. C'S

PREM. C'S

÷60=HRS. ON STD. ——

BASE	OPER'S
.30	.45
C. HR.	.C.H.B.

TIME W'T STD. ——

IND. TIME ——

ALLOWED TIME ——

A.I.T. CREDIT ——

TOTAL CREDIT ——

C. =STD. ——

TOTAL

CALL ——

WAGE ——

PREM. ——

FUND ——

TOTAL ——

FIG. 29.—Unfinished checking card relating to Prob. 8. Use the duplicate for figuration.

THE BLANK CORPORATION

DAILY CHECKING CARD

No. 152

	IN	OUT		IN	OUT
A.M.	8:00	12:00	P.M.	1:00	5:00

NAME THOMAS DOE DEPT. MACHINE DATE JAN. 12, 193—.

CODE	PART NO.	OPERATION	OPER. NO.	MACH. NO.	NO. OF PIECES	MACH. MIN.	N.W.T.*	TOTAL WORK TIME	CREDORS STD.	CREDORS TOTAL	COST PER CREDOR	STD. COST
	147	Bench	4	—	322				2.00			
		Wait for foreman 10'									.005	
		Maintenance 5'									.005	

MIN. IN FACTORY ______

MIN. CREDIT ______

MIN. ON STD. ______

TOTAL WORK TIME ______

A. I. T. ______

STD. C'S WORKED ______

AVG. CREDOR COST

CREDORS

______ STD. C'S

PREM. C'S

÷60=HRS. ON STD. ______

BASE	OPER'S
.30	.45
C. HR.	C.H.B.

TIME W'T STD. ______

IND. TIME ______

ALLOWED TIME ______

A.I.T. CREDIT ______

TOTAL CREDIT ______

C. = STD. ______

TOTAL

CALL ______

WAGE ______

PREM. ______

FUND ______

TOTAL ______

Duplicate Fig. 29.—To be used by the reader for the figuration of Prob. 8.

THE BLANK CORPORATION

DAILY CHECKING CARD

No. 153

NAME EDWARD DOE DEPT. MACHINE

	A.M. IN	A.M. OUT	P.M. IN	P.M. OUT
	8:00	12:00	1:00	5:00

DATE JAN. 12, 193–.

CODE	PART NO.	OPERATION	OPER. NO.	MACH. NO.	NO. OF PIECES	MACH. MIN.	N.W.T.	TOTAL WORK TIME	CREDORS STD.	CREDORS TOTAL	COST PER CREDOR	STD. COST
	3471	Hand feed drill press	2		1060				.25			
		Daywork 250′										
		Wait for drill 11′										
											TOTAL	

MIN. IN FACTORY ____

MIN. CREDIT ____

MIN. ON STD. ____

TOTAL WORK TIME ____

A. I. T. ____

STD. C'S WORKED ____

AVG. CREDOR COST

CREDORS

____ STD C'S

PREM C'S

÷60=HRS ON STD ____

BASE	OPER'S
45	30
C. HR.	C.H.B.

TIME W'T STD.	
IND. TIME	
ALLOWED TIME	
A.I.T CREDIT	
TOTAL CREDIT	
C = STD.	

CALL	
WAGE	
PREM	
FUND	
TOTAL	

FIG. 30.—Unfinished checking card relating to Prob. 9. Use the duplicate for figuration.

THE BLANK CORPORATION

DAILY CHECKING CARD

NO. 153

	IN	OUT		IN	OUT
A.M.	8:00	12:00	P.M.	1:00	5:00

NAME EDWARD DOE DEPT. MACHINE DATE JAN. 12, 193–.

CODE	PART NO.	OPERATION	OPER. NO.	MACH. NO.	NO. OF PIECES	MACH. MIN.	N.W.T.	TOTAL WORK TIME	CREDORS STD.	CREDORS TOTAL	COST PER CREDOR	STD. COST
	3471	Hand feed drill press	2		1060				.25			
		Daywork 250'										
		Wait for drill 11'										

MIN. IN FACTORY ______

MIN. CREDIT ______

MIN. ON STD. ______

TOTAL WORK TIME ______

A. I. T. ______

STD. C'S WORKED ______

AVG. CREDOR COST

CREDORS

______ STD C'S

PREM C'S

÷60=HRS ON STD ______

BASE	OPER'S
45	30
C HR.	C.H.B.

TIME W'T STD. ______

IND. TIME ______

ALLOWED TIME ______

A.I.T. CREDIT ______

TOTAL CREDIT ______

¢ =STD. ______

TOTAL

CALL ______

WAGE ______

PREM. ______

FUND ______

TOTAL ______

Duplicate Fig. 30.—To be used by the reader for the figuration of Prob. 9.

THE BLANK CORPORATION

DAILY CHECKING CARD

No. 154

NAME HARRY DOE DEPT. MACHINE DATE JAN. 12, 193–.

	IN	OUT		IN	OUT.
A.M.	8:05	12:00	P.M.	1:00	5:00

CODE	PART NO.	OPERATION	OPER. NO.	MACH. NO	NO. OF PIECES	MACH. MIN.	N.W.T.	TOTAL WORK TIME	CREDORS STD.	CREDORS TOTAL	COST PER CREDOR	STD. COST
	40F2		1	97	25		18.8%		5.0			
	40F3		8	98	32		21.1		4.5			
	5013		7	56	43		23.2		2.7			
	5706		2	177	50		27.9		3.2			

MIN. IN FACTORY 474

MIN. CREDIT

MIN. ON STD.

TOTAL WORK TIME

A. I. T.

STD. C'S WORKED

AVG. CREDOR COST

CREDORS

STD. C'S

PREM. C'S

÷60=HRS. ON STD.

BASE	OPER'S
.51	
C. HR.	C.H.B.

TIME W'T STD.

IND. TIME

ALLOWED TIME

A.I.T. CREDIT

TOTAL CREDIT

C.=STD.

TOTAL

CALL

WAGE

PREM.

FUND

TOTAL

FIG. 31.—Unfinished checking card relating to Prob. 10. Use the duplicate for figuration.

THE BLANK CORPORATION

DAILY CHECKING CARD

No. 154

	IN	OUT		IN	OUT.
A.M.	8:05	12:00	P.M.	1:00	5:00

NAME HARRY DOE DEPT. MACHINE DATE JAN. 12, 193–.

CODE	PART NO.	OPERATION	OPER. NO.	MACH. NO	NO. OF PIECES	MACH. MIN.	N.W.T.	TOTAL WORK TIME	CREDORS STD.	CREDORS TOTAL	COST PER CREDOR	STD. COST
	40F2		1	97	25		18.8%		5.0			
	40F3		8	98	32		21.1		4.5			
	5013		7	56	43		23.2		2.7			
	5706		2	177	50		27.9		3.2			

MIN. IN FACTORY 474

MIN. CREDIT

MIN. ON STD.

TOTAL WORK TIME

A. I. T.

STD. C'S WORKED

AVG. CREDOR COST

CREDORS

STD. C'S

PREM. C'S

÷60=HRS. ON STD.

BASE	OPER'S
.51	
C. HR.	C.H.B.

TIME W'T STD.

IND. TIME

ALLOWED TIME

A.I.T. CREDIT

TOTAL CREDIT

C. =STD.

TOTAL

CALL

WAGE

PREM.

FUND

TOTAL

Duplicate FIG. 31.—To be used by the reader for the figuration of Prob. 10.

In spite of his high C. Hour, the company was required to make up a base-rate adjustment in order to meet the guaranteed day's pay. Complete the figuration of the card in Fig. 29 using duplicate supplied for Prob. 8. Use the legend "Base-rate Adjustment," which is costed as an excess cost.

NOTE: Since the operator is assigned to a 30-ct. job and is guaranteed his regular day's pay, all details of figuration must conform to the 30-ct. rate; the balancing of the card must be made by the base-rate adjustment.

9. In a plant which observed the 4-hr. clause regarding retention of base rates, Edward Doe, who was a 30-ct. operator, was placed on a 45-ct. base-rate job as in Fig. 30. Besides working on a Time without Standard job, he also received credit for 11 min. check-out time. Although he made a very good C. Hour, he was on standard less than 4 hr. and therefore kept his 30-ct. rate for the work that he did. On account of this condition, a base-rate adjustment became necessary but, instead of the adjustment being an excess cost, it was a saving. Complete the figuration of Fig. 30 using the duplicate supplied for Prob. 9. Use the legend "Base-rate Credit Adjustment."

10. Harry Doe, according to Fig. 31, was late in arriving at work. He operated four machines, all of which produced work that carried different C. Standards and % N.W.T. The notations made by the shop clerk on the back of the checking card for the four machines specified in-and-out times as follows:

Machine 97

Material wait	8:05 to 8:10 =	5 min.
Power shutoff	9:10 to 9:14 =	4 min.
First aid	2:00 to 2:15 =	15 min.
	Total =	24 min.

Machine 98

Tool wait	8:15 to 8:22 =	7 min.
Power shutoff	9:10 to 9:14 =	4 min.
First aid	2:00 to 2:15 =	15 min.
	Total =	26 min.

Machine 56

Power shutoff	9:10 to 9:14 =	4 min.
First aid	2:00 to 2:15 =	15 min.
	Total =	19 min.

Machine 177

Power shutoff	9:10 to 9:14 =	4 min.
First aid	2:00 to 2:15 =	15 min.
Repairs	3:02 to 3:18 =	16 min.
	Total =	35 min.

Machine 97	474 min. minus 24 min. =	450 machine min.
Machine 98	474 min. minus 26 min. =	448 machine min.
Machine 56	474 min. minus 19 min. =	455 machine min.
Machine 177	474 min. minus 35 min. =	439 machine min.

Complete the figuration of Fig. 31 using duplicate supplied for Prob. 10. Allow check-out times to Harry Doe for the power shutoff and for first aid.

Answers to Questions

1. Working day 6 hr. × 60 min. = 360 working min.
8 min. late, penalize $\frac{2}{10}$ = 12 min. penalty
348 min. in shop

2. In the operation of more than one machine where A.I.T. allowances may be granted, the operator receives personal credits only when *all* his machines are stopped simultaneously because of shortage of materials for all of them, power shutdowns, or some other reason beyond the control of the operator.

3. No. As long as an operator remains on standard, no in-and-out time postings are necessary beyond his over-all daily time. While on standard, the operator may work on various standardized jobs, but, since he is paid for Credors produced, no attention need be given to the length of time that he takes on each of the jobs. Certain A.I.T. operations, especially where fill-in jobs do not last throughout the day, must have time-of-completion postings in order to allow properly the correct minutes of available idle time to the operator. Aside from this and day-work jobs, the clerk observes in-and-out times only for check-out times of 3 min. or more.

4. The design of the checking card that is shown in Fig. 23 requires the figuration of data that must cost-balance before the cost clerk can pass the card as completed. This requirement insures accuracy of the cost statements that are later made.

5. 82.5 × 8 hr. = 660 Credors made
60 × 8 hr. = 480 Min. on Std.
180 Premium Credors

48-ct. base rate × 8 hr. = \$3.84 basic wage
\$.008 × 75 per cent × 180 Credors = 1.08 premium earned
\$4.92 total wage

Answers to Problems

6. With reference to Fig. 32, the cost clerk, after ascertaining the minutes in the shop, set up the 52.5 C.H.B. which, when multiplied by 480 min. over 60, allowed 420 machine min. to the learner for his C.H.B. standard minutes. Since the operation carried 90% N.W.T., he was allowed 378 min. as his total working time. It is upon the 378-min. basis that Premium Credors are determined. The C. Hour is always figured from the allowed time on standard. As explained in earlier chapters, the % N.W.T. factor modifies the time on standard.

7. With reference to Fig. 33, Richard Doe was on standard 7.6 hr. because of 24 min. of check-out time for machine repairs. It is noted that, when the check-out time is subtracted from 480 min., the difference of 456 min. must be converted to the 52.5 C.H.B. Time On Standard. Since this operator was "in the red," the plant was required to meet his guaranteed day's pay by allowing him a total of 17 Credors to equal standard. The 50 C. Hour would be posted in red on the Daily Posting Sheets since it is 2½ Credors per hour under the 52.5 base.

8. With reference to Fig. 34, Thomas Doe was on standard for 465 min. and, although he made 83.1 C. Hour, the wage of \$3.07 earned from the base rate of 30 cts. lacked 53 cts. to equal his guaranteed day's pay. Therefore, that difference of 53 cts. was charged to excess costs on the final cost state-

(*Continued on page* 367)

THE BLANK CORPORATION

DAILY CHECKING CARD

No. 150

NAME JOHN DOE DEPT. MACHINE DATE JAN. 12, 193–.

A.M. IN	A.M. OUT	P.M. IN	P.M. OUT
8:00	12:00	1:00	5.00

CODE	PART NO.	OPERATION	OPER. NO.	MACH. NO.	NO. OF PIECES	MACH. MIN.	N.W.T.	TOTAL WORK TIME	CREDORS STD.	CREDORS TOTAL	COST PER CREDOR	STD. COST	
	3M19	Turret lathe	1	330	220	420	90%	378	1.8	396	.008	3	168
		C.H.B. of 52.5 = $\frac{480 \times 52.5}{60}$ = 420 min. on C.H.B. Std.											
		A.I.T. = 42′									.008		336
						420		378		396	TOTAL	3	504

MIN. IN FACTORY 480

MIN CREDIT —

MIN ON STD. 420   420

TOTAL WORK TIME 378

A I T   42

STD C'S WORKED   378

AVG CREDOR COST

396 CREDORS

378 STD. C'S

18 PREM C'S

~~÷ 60 HRS. ON STD.~~ 7.2

8 HRS. X 90% =

BASE	OPER'S
48	42
C HR.	C.H.B.
55.0	52.5

TIME W'T STD.	
IND. TIME	
ALLOWED TIME	
A.I.T. CREDIT	42
TOTAL CREDIT	
C = STD.	

CALL	3	50
WAGE	3	36
PREM.		11
FUND		3
TOTAL	3	50

FIG. 32.—Showing the completed figuration of Prob. 6.

THE BLANK CORPORATION

DAILY CHECKING CARD

No. 151

	IN	OUT		IN	OUT
A.M.	8:00	12:00	P.M.	1:00	5:00

NAME RICHARD DOE DEPT. MACHINE DATE JAN. 12, 193–.

CODE	PART NO.	OPERATION	OPER. NO.	MACH. NO.	NO OF PIECES	MACH. MIN.	N.W.T.	TOTAL WORK TIME	CREDORS STD.	CREDORS TOTAL	COST PER CREDOR	STD. COST	
	3M19	Turret lathe	1	331	190	399	90%	359	1.8	342	.008	2	736
		Repair machine 24'									.007		168
		480' in shop											
		24' delay											
		$\frac{456 \times 52.5}{60} = 399$ min. on C.H.B. Std.											
		A.I.T. = 40'									.008		320
		C = Std. = 17									"		136
		AVG. CREDOR COST				399		359		342	TOTAL	3	360

MIN. IN FACTORY	480	
MIN. CREDIT	24	
MIN. ON STD.	456 = 399	399
TOTAL WORK TIME	359	
A I T.		40
STD C S WORKED		359

342 CREDORS

359 STD C'S

C = Std. 17 PREM C S

$\frac{6.84}{7.6 \text{ Hrs.} \times 90\%}$

BASE	OPER'S
48	42
C. HR.	C.H.B.
50	52.5

TIME W'T STD.	
IND. TIME	
ALLOWED TIME	24
A.I.T CREDIT	40
TOTAL CREDIT	64
C = STD	17

CALL		
WAGE	3	36
PREM		—
FUND		—
TOTAL	3	36

FIG. 33.—Showing the completed figuration of Prob. 7.

THE BLANK CORPORATION

DAILY CHECKING CARD

No. 152

NAME THOMAS DOE DEPT. MACHINE DATE JAN. 12, 193—.

	IN	OUT		IN	OUT
A.M.	8:00	12:00	P.M.	1:00	5:00

CODE	PART NO.	OPERATION	OPER. NO.	MACH. NO.	NO. OF PIECES	MACH. MIN.	H.W.T.	TOTAL WORK TIME	CREDORS STD.	CREDORS TOTAL	COST PER CREDOR	STD. COST	
	147	Bench	4		322				2.00	644	.005	3	220
		Wait for foreman 10'									.005		050
		Maintenance 5'									.005		025
												3	295
		Guaranteed pay 45 x 8 = $3.60											
		Pay at base rate $2.40											
		Premium .67		3.07									
		Base rate adjustment		.53									53

MIN. IN FACTORY	480		
MIN. CREDIT	15		
MIN. ON STD.	465		
TOTAL WORK TIME			
A. I. T.			
STD. C'S WORKED		465	

AVG. CREDOR COST

644	CREDORS
465	STD C'S
179	PREM C S
÷60=HRS ON STD	7.75

BASE	OPER'S
.30	.45
C HR.	C.H.B.
83.1	

	644
TIME W'T STD.	
IND. TIME	5
ALLOWED TIME	10
A.I T. CREDIT	
TOTAL CREDIT	15
C. =STD.	

TOTAL	3	825
CALL	3	82
WAGE	2	40
PREM		67
FUND		22
B.R.A.		55
TOTAL	3	82

FIG. 34.—Showing the completed figuration of Prob. 8.

THE BLANK CORPORATION

No. 153 DAILY CHECKING CARD

	IN	OUT		IN	OUT
A.M.	8:00	12:00	P.M.	1:00	5:00

NAME EDWARD DOE DEPT. MACHINE DATE JAN. 12, 193–.

CODE	PART NO.	OPERATION	OPER. NO.	MACH. NO.	NO OF PIECES	MACH. MIN.	N.W.T.	TOTAL WORK TIME	CREDORS STD.	CREDORS TOTAL	COST PER CREDOR	STD. COST	
	3471	Hand feed drill press	2		1060				.25	265	.0075	1	988
		Daywork 250′									.005	1	250
		Wait for drill 11′									"		055
												3	293
		Base rate credit adjustment											54
												2	753

MIN. IN FACTORY	480	
MIN CREDIT	261	
MIN. ON STD.	219	
TOTAL WORK TIME		
A. I. T.		
STD. C'S WORKED		219

AVG. CREDOR COST

265	CREDORS
219	STD C S
46	PREM C S
÷60 = HRS. ON STD.	3.65

BASE	OPER'S
45	30
C HR	C H B.
72.6	

	265	TOTAL		
TIME W'T STD.	250	CALL	2	75
IND TIME		WAGE	2	40
ALLOWED TIME	11	PREM.		26
A.I.T CREDIT		FUND		9
TOTAL CREDIT	261	TOTAL	2	75
C = STD				

FIG. 35.—Showing the completed figuration of Prob. 9.

THE BLANK CORPORATION

DAILY CHECKING CARD

No. 154

NAME Harry Doe DEPT. Machine DATE Jan. 12, 193—.

	IN	OUT
A.M.	8:05	12:00
P.M.	1:00	5:00

CODE	PART NO.	OPERATION	OPER. NO.	MACH. NO.	NO. OF PIECES	MACH. MIN.	N.W.T.	TOTAL WORK TIME	CREDORS STD.	CREDORS TOTAL	COST PER CREDOR	STD. COST
	40F2		1	97	25	450	18.8%	85	5.0	125	.0085	1 063
	40F3		8	98	32	448	21.1	95	4.5	144	"	1 224
	5013		7	56	43	455	23.2	106	2.7	116	"	986
	5706		2	177	50	439	27.9	123	3.2	160	"	1 360
		Power off 4′									"	034
		First aid 15′									"	128
		A.I.T. 46′									"	391
								409		545	TOTAL	5 186

MIN. IN FACTORY	474	
MIN. CREDIT	19	
MIN. ON STD.	455	455
TOTAL WORK TIME	409	
A. I. T.		46
STD. C'S WORKED		409

AVG. CREDOR COST

545	CREDORS
409	STD. C'S
136	PREM. C'S

÷60=HRS. ON STD. 6.82

BASE	OPER'S
.51	
C. HR.	**C.H.B.**
80.0	

TIME W'T STD.	
IND. TIME	4
ALLOWED TIME	15
A.I.T. CREDIT	46
TOTAL CREDIT	65
C. = STD.	

CALL	5 19
WAGE	4 03
PREM.	87
FUND	29
TOTAL	5 19

FIG. 36.—Showing the completed figuration of Prob. 10.

ment. From the standpoint of the checking card, his day's wage was considered as follows:

$2.40	basic pay at 30-ct. base rate
.67	premium earned
.53	base-rate adjustment
$3.60	total pay for the day

9. Since Edward Doe was on standard less than 4 hr., his basic pay and check-out times were costed at the 30-ct. rate, although his premium money of 26 cts. accrued from the regular 45-ct. base rate. Figure 35 shows the 54-ct. base-rate credit adjustment necessary to preserve the $2.75 cost balance.

10. Because of a tardiness penalty of 1/10th hr., Harry Doe was in the shop only 474 min.; consequently his basic wage was 474 min. × .0085 = $4.03. The combination of work that was assigned to him did not "load" him and therefore 46 min. of A.I.T. was allowed. See Fig. 36 for other data.

Chapter XIX

Seldom is an attempt made to time-study inspection operations because of the feeling on the part of many plant officials that the inspectors might slight their duties in their desire to reflect high records of performance. Inspectors can participate in a wage-incentive plan if suitable credits are granted for all good work that is passed, if bad work is properly rejected and if penalties are levied for improper decisions.

Chapter XIX outlines the methods that are successfully used to apply inspection and salvage operations in different types of industry. The basic principles given in this chapter can be followed, but the actual energy and monetary values specified here may require slight changes in order to suit the demands of certain peculiar inspection requirements.

CHAPTER XIX

APPLYING INSPECTION OPERATIONS

One of the factors contributing to the success of any manufacturing plant is its inspection department. It will be found that the more modern and progressive a plant is, the more stress is laid on its inspection requirements. To maintain standards of precision and finish, these plants give serious thought to the proper kind of thorough inspection for their products, with the result that a sizable percentage of their manufacturing costs may be traced to inspection operations. Other plants feel that inspection operations are merely overhead expenses and should be treated as necessary evils associated with manufacturing.

Very few plants of the two general types mentioned give enough consideration to the inspection output per man. These plants may deliberate on the expected production per day from their direct operators, but usually the inspection operations are satisfied by a volume of men per inspection, rather than a volume of inspection per man.

It is in the inspection departments that the T.S.M. finds a fertile field for time study. It has been proved many times that inspection operations can be studied and standards for them set up that result not only in large savings but in better quality and better control of that quality. This has exploded an old theory that inspectors must not be hampered by time studies that confine their work to time limits.

The inspection operations are generally the last jobs to be time-studied and applied. Pending that time, the T.S.M. has familiarized himself with all of the productive operations in the department. He knows the function of each part that is made as well as its permissible limits of accuracy and its finish; he is familiar with the machines on which each part was made and knows the caliber of the operator producing it. Thus, the T.S.M. has a comprehensive knowledge of the work to be inspected, which is of great help to him in the analysis and timing of the inspection operations.

The inspection of parts in process or of finished products is required in order to maintain equal uniformity of work by keeping it within predetermined limits of error. These limits concern the accuracy of size, relationship of assembled parts, specification of materials, color, finish, and many other things, all of which we shall classify under the word "quality."

To identify the quality of the work produced is to compare it with standard specifications. Since the specifications are built according to the duty that each manufactured part is to perform, they prescribe limits of error or permissible differences within which quality must be confined. These limits may be tangible things, such as definite regulations set forth by written instructions or blueprints. The regulations may be met by the use of measuring tools or tests or by comparison with samples as to color, finish, texture, etc. So far as time-study work is concerned, inspection work may be grouped into two fundamental classifications:

1. *Definite inspection.* Determined by gauges, tools, tests, or other physical means that are positive in their effectiveness.
2. *Indefinite inspection.* Determined by matching or by comparison with samples that require a discrimination on the part of the inspector resulting from unusual eyesight, keen judgment, or peculiar training.

In the first case, the T.S.M. can directly measure the inspection, whereas, in the second, he must be guided in his measurement by a degree of judgment comparable to that which is shown by the inspector.

Whenever work is visually inspected and compared with samples, the samples should indicate the extremes of tolerance rather than a mean or a halfway medium. For example, if an inspector is required to pass judgment on the ground finish of a part, he should be given two samples, one of which represents the degree of finish permitted for work that is barely passable and the other a finish that cannot be consistently maintained without undue manufacturing cost. This same scheme should be applied to permissible extremities of color, texture, etc. Thus, the fixation of go and no-go samples for indefinite types of inspection helps the T.S.M. in his task of setting up C. Standards that will not impair quality.

In his approach to the analysis of inspection operations, the T.S.M. assumes that the members of the engineering department

in the plant have prescribed quality specifications that are correct. It often happens, however, that a designer will, without mature thought, assign limits of quality that are not advisable and, consequently, increase the cost of the product. To specify .001 in. as a limit of accuracy when .002 in. is permissible is to increase that accuracy by 100 per cent. Many thousands of dollars may be lost each year in the observance of a limit that is not vitally necessary to the preservation of quality.

Having studied all of the operations that comprise the manufacturing process of a part, the T.S.M. is often in a position to recommend that appreciable savings be gained by modifying the tolerance limits of parts to an extent that still in no wise affects their quality during the process or in the final assembly.

Inspection operations are handled in either centralized or floor stations. The former consists of a section, bench, crib, room, or department where the work to be inspected is moved in and out by hand, by truck, or by moving belts. If work is inspected from a centralized point, it means bringing the work to the inspector, which may or may not be the cheapest procedure. One of the conveniences of centralized inspection is that cheaper types of inspectors can be employed on account of the closer supervision that can be given to concentrated groups of inspectors. Female labor is usually employed for the inspection of small parts. Centralized inspection often proves to be a costly convenience when the cost of trucking is carefully considered. Also, all work withdrawn from a flow of materials is just so much dead stock, hence greater inventories and more capital investment for work in process. A piece of work should be promptly inspected and then released as quickly as possible so that it is only momentarily delayed in the material flow. If a box containing 1,001 small brass parts is being inspected by one person and it requires half a minute to inspect each piece, 1,000 pieces are unnecessarily held up or 500 material min. are wasted while disposition is being made of the whole box. This time wastage is further increased if the box of parts is delayed in storage or transit before or after inspection.

The opposite of centralized inspection is floor inspection, which means sending the inspector to the job. This latter type of inspection usually calls for a more intelligent person who receives higher wages for his work. He is not subject to as close super-

vision as the others and, consequently, must have more initiative or ability to meet the inspection problems and to dispose of them properly. The disposition of many of his problems calls for unusual discrimination, decision, and good judgment in the stopping of machines or in the altering of work to protect quality. A traveling inspector who is assigned to definite patrol duties of inspection may, even though paid more, prove more profitable than a cheaper one who is localized in one designated spot. It is a part of the T.S.M.'s duties to subject inspection operations to the same analysis as is given to regular productive operations.

Each departmental inspection operation should be further classified into raw, semifinished, or finished divisions, whether it be rough foundry work or precision parts that are handled in the final assembly. After this is done, the T.S.M., in consultation with the superintendent and the chief inspector, should arrive at the percentage of inspection required, *i.e.*, whether a part should have 10 or 100 per cent inspection. Percentage inspection is usually applied to automatic machines producing small parts in large quantities. In this type of inspection, the inspector picks sample parts at random from the mass. Some plants establish a ruling that, if one or more defective parts are found when they are picked at random from the quantity, the whole lot must be individually examined. Other plants use the sampling inspection for maintenance of proper machine setups and performance in the belief that the improper parts will be caught by the operators on the final assembly. Sometimes the slight inconveniences which are imposed on assemblers in disposing of improper work is far cheaper than giving 100 per cent inspection treatment to parts that either will or will not fit in the finished product.

Before consulting with the superintendent and chief inspector, the T.S.M. should check through repair and service records, salvage and scrap reports, and any other data that will give him a clearer picture of the aims and accomplishments of the inspection department. In the light of true economy, the inspection for each part should be viewed from many angles. The next several paragraphs will outline some of those angles:

Is the inspection thorough enough? Inspection can do at least two things: it can prevent errors, or it can catch them after they are made. A study of scrap or salvage reports often dictates the wisdom of installing additional

inspectors in order to prevent errors. The answer is that, if costs are lowered or if quality is to be protected, then increased inspection should be installed.

Is the inspection partly or wholly unnecessary? Many operations, by reason of good workmanship of machines or men, yield excellent work without inspection. It can often be proved from scrap, salvage, repair, and service records that inspection of certain operations is not necessary. It frequently happens that, although new machines or methods have been installed in order to prevent errors, the severity of the inspection, because of neglect, was not properly modified after their advent.

Are the limits too severe? By this is meant the limits that have been set for work in process. There is no economy in establishing a close limit for a part that perhaps is later altered in process or has no direct connection with other parts in the assembled unit. Close limits that are specified for work in process can often be modified by giving consideration to machines, tools, or methods which, if changed slightly, might permit of greater limits during the processing.

Are the limits controlled by man or machine? Precision work that is produced from manual or machine operations where the man's skill is the determining factor in resultant accuracy is subject to closer inspection than work produced by machines that are automatic or are equipped with stops or sizing devices. The types and conditions of machines used are items that must be recognized before many inspection operations can be evaluated. There are many types of machines that perform accurately only because of the frequent adjustments made to them. Thus, the inspector cannot wait until the whole quantity of work has been completed but must give periodic inspection to the job in order to anticipate machine adjustments.

Does the setup man or the foreman inspect the first piece? The inspection policies vary in different plants. Some managements feel that their foreman and setup men are the chief agents in securing quality from the operations and therefore are better informed as to the requirements. Having this attitude of mind, the inspection department only checks the efforts of the responsible agents and keeps the quality within due bounds. Since the quality burden is borne on the shoulders of others, the inspection is not responsible for the first pieces of work that are made. Other managements contend that their inspectors are directly responsible for all good or bad work that is made and the manufacturing personnel is subordinated in this respect to inspection demands. The T.S.M. should understand the management's interpretation of its chief inspector's relation to the manufacturing departments, because a greater amount of time must be allowed to inspection standards if the inspection department occupies a primary instead of a secondary position in the plant. In other words, an inspector must be allowed more time for his effective effort if he is called upon to prevent and find errors, than if he merely discovers errors after their occurrence.

Does material value influence greater inspection? It will generally be found that the greater the value of raw materials, the more rigid is the necessary inspection. Not only are the raw materials carefully examined but their stages of completion are watched more closely. Bearing in mind

that costly raw materials rapidly increase in value as they near completion, the T.S.M. must make due allowances for the inspector's mental strain which accompanies such work. Should the properties of the raw materials vary to the extent that manufacturing liabilities are increased, this fact must receive consideration in inspection standards.

Are parts shipped separately or in finished units? The assembly rooms of plants are often the clearinghouses for defective work and elaborate inspection methods that are used to pass the final machine operations of certain parts are wasted costs when it is known that the final assembly will automatically reject work that does not function with mating parts. The advantage of process inspection is that immediately it stops defective work before it accumulates further unnecessary costs. There are occasions, however, when it is less costly to complete the last one or two operations of a part without inspection and to discover the error at the assembly. For example, if the last machine operation on a shaft costs \$.015 and the inspection of that operation costs 2 cts., it may prove advisable to omit the inspection provided that the later assembly of the part reveals the error at a cost of less than 2 cts.

If precision parts are shipped outside the plant, the inspection requirements should be more severe, unless an agreement is reached whereby the assembling customer, in view of a lower selling price that was made possible by lessened inspection costs, will act as the final inspector on his assembly work and will return for credit all work that has been improperly done.

Can design of tools eliminate inspection? Jigs, fixtures, and other work-holding devices are usually designed for such simplicity that little thought is given to the possibility that these devices might aid inspection. For example, if an inspector patiently tries a go and no-go gauge on work prior to the next machine operation, that same go and no-go principle might be applied to the fixture on the next operation and thereby eliminate an intermediate inspection.

When the T.S.M. is satisfied that the inspection specifications are thorough and offer clean-cut instructions, and when he has familiarized himself with them, he is ready for the next step, that of classifying the elements of inspection items of work.

In previous chapters, constants, changeables, variables, and incidentals were discussed. These same principles apply to the elements that are set up for inspection operations. Just as the elements that cover graduated sizes of products can be refined into graduated time measurements, so can many of the work elements that cover inspection be handled. For example, the general handling of micrometers requires more effort as the size of the micrometer increases. Also, the inspection limits per micrometer size influence the time required for measuring. The T.S.M., after accumulating data in time studies from direct operators who used micrometers, can make up charts which show

normals for the various limits that have been measured by different sizes of micrometers, as follows:

Size of micrometer, inches	Limits in inches as specified by inspection data						
	.0002	.0005	.001	.002	.003	.004	.005, etc.
1 2 3 4 5 6 etc.	(Fill in the graduated normals.)						

These same chart ideas can be created for snap-gauges, length gauges, and many other styles of inspection instruments. In the case of visual inspection, the T.S.M. can often use size or surface-area factors for the relation of inspection normals. For example, if an inspector must pass judgment on rolls of fabric, he should be allowed more time to inspect 1 yd. of material 36 in. wide than 1 yd. which is 24 in. wide.

The time studies for centralized inspection operations are apt to be less involved and consist of fewer elements than those for floor inspection. In the latter, there are usually more elements that cover walking times, variables, incidentals, allowances for time to discuss work that is to be reworked or scrapped, and many other items which are not found in work inspected in one spot. Then, too, there is the condition where the plant's products are of a miscellaneous nature and are made in such small job lots that the C. Hours of the floor inspectors show marked fluctuations and apparently do not reflect the true amount of energy that has been expended. In cases of this kind, it is sometimes advisable to credit the inspector with the amount of work produced by the direct operator rather than the amount actually inspected and to arrive at his C. Hour by use of the departmental C. Hour. In other cases, it seems desirable to treat certain inspectors as regular indirect workers and to allow them incentives that accrue from funds or other forms of bonuses that contain measures for rewarding or penalizing on a basis of quality factors as well as gross output. More will be said in Chap. XXI about inspectors who are considered as indirect workers.

After the T.S.M. has analyzed, timed, and rated inspection operations, C. Standards are built for them in the same fashion as for regular productive operations. Thus, the inspector can show Credor-hour performances based on the energy that he has expended in order to inspect a volume of work. However, unless there is some governing principle connected with this possibility, the inspector might sacrifice accuracy of inspection in his endeavors to show high inspection performance.

This contingency is taken care of by two provisions. The first is the use of a second C. Standard which is found by time study and which represents the effort to confirm and dispose of each defective piece of work properly. The second provision is the use of a percentage factor to accompany the two standards. This percentage factor is called an "Inspection Credit" and is made attractive enough to inspire the inspector to do his work accurately and to find all the defective parts in the amount of work given to him for examination. Thus, he has for each inspection operation two standards and an inspection credit to take care of quantity and quality.

An Inspection Credit for each inspection operation is arbitrarily set up after a thorough analysis of inspection, scrap, and salvage reports, which extend over the Reference Period or any other representative manufacturing period. From these reports are determined the average percentage of rejection as a result of inspection and the relative importance of close inspection control at that particular operation. The fewer the defective parts, the harder they are to find and the inspector should accordingly receive a proper Inspection Credit as a further incentive for his ability to search, find, examine, and remove defective parts from the good parts. An Inspection Credit applies only to each defective piece that is found. Experience has indicated that a 10 per cent additional incentive is suitable for Inspection Credits.

The formula for the figuration of Inspection Credits is as follows:

$$T = \frac{(G \times A + B \times D) \times C \times B}{P \times 1{,}000}$$

where T = total inspection Credit Credors allowed
G = total good pieces of work passed
A = C. Std. for each good piece of work
B = total bad pieces of work rejected

D = C. Std. for each bad piece of work
P = the normal percentage of rejections set up for the job, such as .12, .15, .28, etc.
C = the Inspection Credit percentage arbitrarily expressed as 10 per cent or some other suitable incentive

Illustrating the use of the above formula, we shall assign values to the symbols:

T = the total extra Credors allowed to the inspector
G = 2,720 good pieces of work passed by him
A = .2 min. C. Std. per good piece
B = 240 bad pieces of work rejected by him
D = .4 min. C. Std. per bad piece
P = 15 per cent = the usual or normal percentage factor set up after a study of past records = .15
C = 10 per cent incentive allowed as Inspection Credit

Applying these values to the formula we have

$$T = \frac{(2{,}720 \times .2 \text{ min.} + 240 \times .4 \text{ min.}) \times 10 \text{ per cent} \times 240}{.15 \times 1{,}000}$$

$$= \frac{640 \times .10 \times 240}{150} =$$

102 extra Credors earned as Inspection Credits

The inspector's Credor-hour performance is *always* computed from the regular Credors made and *never* includes the extra Credors earned as Inspection Credits, because the latter are a measure of quality and not quantity. In the above example, the inspector made 640 Credors. Had this performance accrued from 8 hr. on standard, he would have earned 80 C. Hour for his effort. Carrying the example still further by assuming that he has a 48-ct. base rate and that Premium and Inspection Credits are valued at 75 per cent of the Credor Cost, the inspector's pay for his 8-hr. performance is

Inspection of parts =	640 Credors
Time on standard =	480 min.
	160 Premium Credors
	102 Inspection Credits
	262 total Premium Credors
$\frac{\$.48}{60} \times 75$ per cent $\times 262$ =	\$1.57 premium money
8 hr. in shop $\times$ 48 cts. =	3.84 base wage
	\$5.41 total wage for the day

The total incentive offered in this case is about 41 per cent over the base-rate wages. If it was decided that $5.41 is too high for the type of inspection work involved, a lower base rate can be assigned to the inspector rather than a cutting down of the incentive offered by the Inspection Credits.

In their zeal to find bad work, some inspectors might go so far as to reject good pieces unless some control of this possibility is exercised. All good pieces thus thrown out in inspection are called "false rejects." Since all rejected work should be confirmed by other members of the inspection department, the false rejects are later found and are again placed in the production flow of materials. As a penalty against the offending inspector for his irregular proclivities, all improperly rejected pieces of work should be charged back against him by use of a penalty standard that is considerably greater than the C. Standard allowed for the inspection of bad pieces. For example, in the foregoing illustration, a .4-min. C. Std. was set up by time study which was used for each of the 240 bad pieces of work that were found. If it was learned that several of the pieces in that quantity were false rejects, a penalty of, say, 5 min. per piece could be charged against the inspector for each piece that was improperly rejected. A penalty standard that has been arbitrarily fixed should be large enough so that its imposition will not only compensate for the extra Inspection Credits which have been erroneously allowed but will punish the inspector in a financial way that will discourage his attempts to misjudge work dishonestly or carelessly.

All work, whether properly or improperly rejected, should be sent to a salvage department for final examination and disposition. To prevent any collusion between the inspection and the salvage departments, the salvage inspectors should be paid flat daily wages plus a bonus based on the value of the materials which had been erroneously rejected and which they release for manufacturing use; or on the value of parts that can be salvaged by rework operations.

One of the liabilities likely to be encountered is the possible improper recommendations that may be made for parts to be salvaged by rework operations. Unless some control is instituted, a few of the salvage inspectors, in order to reflect higher salvage values, might release certain parts which call for treatments that may prove to be failures and might thereby add

further unnecessary costs to work that should be condemned. To obviate this liability, the bonus paid to salvage inspectors should be controlled by two factors:

1. For work which has been released by the salvage department as false rejects or for rework treatment, a bonus will be paid provided that the recommendations prove to be 92 per cent or more correct. *Example:* the salvage department released 100 pieces either as being falsely rejected or as being subject to reworking. After final disposition was made of the lot, a quantity of 93 pieces was actually saved. Therefore, the salvage inspector is entitled to a bonus because 93/100ths or 93 per cent is within the dead line.

2. For work which has been released by the salvage department as false rejects or for rework treatment, a bonus will not be paid if the recommendations are less than 92 per cent correct.

With reference to factor 1, the first step is to determine the number of Premium Credors to be allowed for each hour that the salvage inspector spent on the salvage duties. Assuming that 25 Premium Credors per hour is a satisfactory reward for 100 per cent correct recommendations, a curve may be drawn showing the allowed hourly Credors for the various percentages between 92 and 100 per cent. The curve can then be made in tabulated form similar to Table 7, as follows:

TABLE 7

Percentage of Correctness for Salvaged Work	Premium Credors Allowed per Hour
100	25
99	22
98	19
97	16
96	13
95	10
94	7
93	4
92	1

To illustrate the use of the above table, let us assume that a salvage inspector is in a 30-hr. week plant. Let us further assume that his entire monthly time of 130 hr. was spent on salvage work. During that time, the following different jobs passed through his hands and, out of the quantities that were recom-

mended by him for reworking, the following quantities were saved:

Part number	Pieces recommended for reworking or for release as false rejects	
	Total quantity	Quantity finally saved
3F-19	1,500	1,400
3B-40	3,200	2,960
1,521	150	135
793-H	650	665
1,506	1,225	1,120
2,329	985	900
	7,710	7,180

His recommendations are then 7,180/7,710ths, or 93 per cent correct. Based on Table 7, he is allowed 4 Premium Credors, or 130 hr. × 4 = 520 total Premium Credors for the month.

Salvage operators do not show Credor-hour performances because their work is not time-studied, since it is of such a miscellaneous nature and since the effort to pass judgment on each piece of work is not the same. Consequently, in order to stimulate the salvage inspectors to work briskly, the value of their Premium Credors is conditioned on the total monetary values of the work that has been salvaged for the month. The more pieces are saved per month, the higher the value of the salvage work. On this premise, the second factor that is used for the control of salvage will be explained.

Table 8 shows the ordinates obtained from a curve drawn for the material values in a plant where the salvage per month fell within the \$5000 range. This table supplies the value for each Premium Credor as found from Table 7.

In using Table 8, the value of the monthly corrected or released work which resulted from salvage treatment (not the value of the parts sent into salvage) is obtained from the cost department data, and against that nearest amount in the table is found the corresponding Premium Credor value which, when multiplied by the Premium Credors which were obtained from Table 7 figuration and by the hours spent on salvage, results in the bonus earned over the base wage for the month.

TABLE 8

Value of Salvaged Monthly Material	Allowed Value per Premium Credor
$ 100	$.0002
200	.0003
300	.0005
400	.0007
500	.0009
600	.0010
700	.0012
800	.0014
900	.0015
1,000	.0017
1,100	.0018
1,200	.0020
1,300	.0022
1,400	.0023
1,500	.0025
2,000	.0033
2,500	.0042
3,000	.0050
3,500	.0058
4,000	.0067
4,500	.0075
5,000	.0083

To exemplify the figuration for Table 8, let us assume that the 7,180 parts actually saved (page 382) through salvage department recommendations have a cost value of $2500 immediately after the point of rework. Referring to Table 8, a Premium Credor value of $.0042 is indicated. This value, multiplied by the 520 Premium Credors earned, yields a product of $2.18 which is the premium or bonus money paid to the salvage inspector for being 93 per cent correct in his recommendations regarding false rejects or work that could be saved by extra treatment. Had his recommendations concerning the 7,710 pieces been 100 per cent correct, he would, according to Table 7, have been entitled to 25 hourly Credors or

$$\frac{25 \times 130 \times \$.0042}{93 \text{ per cent}} = \$14.68 \text{ extra earnings for month}$$

The values given in Tables 7 and 8 should not be used by the reader for applying salvage departments without careful check, because the salvage problems in each plant may demand higher or lower value ranges than those which are shown.

To return to the subject of centralized or floor inspection, some inspectors may be so anxious to find defective work that their Credor Hours will fall below normal and consequently their performances will call for Credors to equal standard. To take care of this possibility, a ruling should be established as follows:

> When an inspector's Credor-hour performance falls below 60 as a result of his endeavors to earn Inspection Credits, the Credors to equal standard which are allowed for subnormal performance must be subtracted from the Inspection Credit Credors before the premium (if any) is computed.

To amplify this rule: An inspector might slow up his effective speed and, although he may have found several pieces of defective work, he might as a consequence be "in the red" so far as his C. Hour is concerned. It would be unfair to allow him Credors to equal standard in addition to his Inspection Credits; therefore, his premium should be computed from the difference between the two. Of course, if the inspector's C. Hour is above normal, no deductions or reconciliations are necessary. The three following examples will illustrate the Inspection Credit principles as handled on checking cards:

Example 1.

40 Credors to equal standard
35 Inspection Credits earned
5 C.=Std. (Wipes out premium)

Example 2.

35 Inspection Credits earned
20 Credors to equal standard
15 Inspection Credits

Example 3.

150 premium Credors earned
35 Inspection Credits earned
185 total premium Credors

On sampling inspection, the shop clerk enters on the checking card the total number of pieces in the lot and the number that were actually examined in the lot. In addition to these data, the shop or cost clerk also enters the inspection percentage requirements. For example, if the inspector samples 10 per cent of 10,000 punch-press parts, the 1,000 pieces that were actually examined are kept separate from the lot until their count and percentage are verified. Thus, the checking-card posting becomes

10,000 received 10 per cent required 1,000 checked

Besides the possibilities of having certain assemblers (along with their regular work) act as inspectors, machine operators who have A.I.T. can be trained to handle inspection operations and thereby to absorb their idle time. In such cases, the regular operator, in addition to his operational C. Standards, receives the benefit of inspection fill-in work, the C. Standards and Inspection Credits for which are also allowed to him.

Where inspectors are given incentives for their work, a plan must be worked out so that their gauges and measuring instruments may be periodically inspected. This systematic plan of handling gauges is usually handled by the tool- or gauge-manufacturing divisions which are responsible for the condition and accuracy of the inspectors' tools. The employees in these divisions are not usually included in inspection-incentive plans because they receive the prevailing wage for their work in the same manner as tool and gauge makers.

The chief inspector and his immediate assistants are also left out of the incentive plan. They are paid suitable salaries in the pursuit of their work to see that the quality of product is maintained. It is possible, however, for the higher inspection officials to receive bonuses based on general plant averages—an integrated quality factor being used as one of the determining media.

The quality of today may not be satisfactory for tomorrow. As materials, machines, and methods are constantly changing, the inspection requirements must keep pace with modern industrial activity. Therefore, since quality is in a continual state of transition, the C. Standards which cover inspection are subject to change.

After the T.S.M. has applied inspection departments, he should compute the ratio of inspectors to workers. Some plants manufacturing precision products have one inspector to every four or five workers, whereas other plants may enjoy a ratio of 1 to 50. Having obtained the ratio and perhaps the ratio of inspection costs to over-all costs, the management officials are in a better position to compare their inspection data with those of other plants which are sometimes available to them through their contacts in competitive fields.

Questions

1. Why is the T.S.M. able to analyze, time-study, and apply the inspection operations in a department?

2. Name the three incentive principles in addition to suitable base rates that can be offered to inspectors for accurate inspection work.

3. Does the figuration of an inspector's Credor-hour performance ever include the Credors earned as Inspection Credits?

4. Can provisions be made to penalize inspectors for false rejects?

5. Name the incentive principles in addition to suitable base rates that can be offered to salvage inspectors for careful attention to work sent to the salvage department.

Problems

6. An inspector is given the operation of inspecting some toys which carries a .15-min. C. Std. for each good toy and .30-min. C. Std. for each bad one. In addition, he is allowed a 10 per cent Inspection Credit. His base rate is 42 cts. and, during his 6 hr. on standard, he passed 2,900 good toys and rejected 50 bad ones. A normal percentage of 2 per cent is set up as the usual rejection on this job. Complete the figuration for the inspector's day's wage where all Premium Credors and Inspection Credits are valued at 75 per cent of the Credor Cost. Also specify the inspector's Credor-hour performance..

7. Another 42-ct. base-rate inspector was assigned to the same inspection job with the same basic conditions as outlined in Prob. 6 above. However, he was allowed ½-hr. check-out time for miscellaneous reasons and consequently was on standard for only 5½ hr. out of the 6 hr. that he was in the plant. While on standard, he passed 2,065 good toys and rejected 20 bad ones. What was his daily wage and what was his Credor-hour performance?

8. Solve the inspector's total wage and Credor-hour performance on the basis of the following:

6 hr. in the plant
.6 hr. on day work
.4 hr. first aid
334 good parts passed

1.3 min. C. Std. per good part
17 parts rejected
2.1-min. C. Std. per bad part rejected
10 per cent allowed for Inspection Credits
3 per cent normal rejection specified
15 false rejects from previous day
4-min. C. Std. penalty for each false reject
48-ct. base rate
All Premium Credors based on 75 per cent of Credor cost.

9. A salvage inspector who receives a base rate of 45 cts. per hour spent 125 hr., out of his 130 hr. in the plant during the month, on salvage work. In that time on standard, he examined a quantity of 3,650 miscellaneous parts that had been rejected by the regular inspectors. After carefully reinspecting all the parts, he released 3,000 of them as either false rejects or work that could be saved by reworking. Acting upon his recommendations, the plant was able to save 2,940 parts valued at $3,500. What was the total money that was paid to the salvage inspector for his month's work? Use Tables 7 and 8 in this chapter.

10. Another salvage inspector, receiving a base rate of 45 cts. per hour, spent 124 out of his 130 hr. in the plant on salvage work. During that time he released 450 pieces of work with attached recommendations. The shop finally saved 407 of the pieces valued at $2,750. What was the total money paid to him for his month's work? Use Tables 7 and 8 in this chapter.

Answers to Questions

1. The ability to analyze inspection operations requires, among other things, a first-hand knowledge of the work to be examined. Since the inspection operations are the last departmental applications which are made, the T.S.M. has acquired a thorough understanding of the inspection conditions and problems to be standardized. This understanding was gained during the period that he time-studied the manufacturing of the work. Thus, knowing the function of each part, its material, the permissible limits of accuracy, its finish, the importance of its inspection, the machines on which it was made, and the caliber of the operators who produced it, the T.S.M. is equipped with the ability necessary to standardize inspection work properly.

2. The three incentive principles that can be offered, in addition to attractive base rates, to inspectors for accurate inspection work are standards allowed as follows:

a. A C. Standard for all good work passed.

b. A C. Standard for all bad work rejected.

c. An Inspection Credit for bad work rejected. This is usually a 10 per cent allowance.

3. No. Inspection Credits are measures of quality and not of quantity. The effective efforts of an inspector result in an output that may be greater or less because of the recognition of quality embodied in quantity. Therefore, since Credor-hour performances are direct measures of the energy that

has been expended for producing the quantity, the Credors which are earned as Inspection Credits are never considered in the figuration of Credor-hour performances.

4. Yes. All improperly rejected work should be charged back against the inspector by means of a penalty C. Standard. This standard, which is arbitrarily established by the management, should be large enough to compensate for Inspection Credits that have been erroneously allowed and also to punish the inspector financially for careless or dishonest judgment of work. Levy of the penalty on the checking card is made whenever false rejects are found, though their discovery may be delayed days or weeks.

5. The incentive principle that can be offered to salvage inspectors is a weekly or monthly bonus which is conditioned on

a. A scale of factors, similar to Table 7, covering the percentage of correctness of the recommendations that have been made which allow hourly Premium Credors for false rejects or for rework treatment that will release the work into the flow of manufacturing materials.

b. The value of the hourly Premium Credor in (*a*) is based on the monetary value of the materials that have been actually salvaged during the pay period as suggested by Table 8.

6. Good toys, 2,900 × .15 min. = 435 Credors made
Bad toys, 50 × .30 min. = 15 Credors made
450 total Credors
6 hr. × 60 min. = 360 min. on Standard
90 Premium Credors

$$\frac{450 \times .10 \times 50}{2 \text{ per cent} \times 1{,}000} = \frac{2{,}250}{20} = 112 \text{ Inspection Credits}$$

202 total Premium Credors

Base rate = 42 cts. × 6 hr. = \$2.52 base wage

$$\frac{\$.42}{60} \times 75 \text{ per cent} \times 202 = 1.06 \text{ premium earned}$$

\$3.58 total wage

$45\% = 75$ C. Hour

Proof:

435 × \$.007 = \$3.045
15 × \$.007 = .105
112 × \$.007 = .784
Total cost = \$3.934
Total wage = \$3.58
\$.007 × 25 per cent × 202 = .35 3.930
Error = \$ .004

7. Good toys, 2,065 × .15 min. = 310 Credors made
Bad toys, 20 × .30 min. = 6 Credors made
316 total Credors
6 hr. × 60 min. − 30 min. = 330 min. on Standard
14 C. = Std.

$$\frac{310 \times .10 \times 20}{2 \text{ per cent} \times 1{,}000} = \frac{632}{20} = 32 \text{ Inspection Credits}$$

18 net Premium Credors

Base rate = 42 cts. × 6 hr. = \$2.52 base wage

$\frac{\$.42}{60} \times 75 \text{ per cent} \times 18 =$ .09 premium earned

\$2.61 total wage

$\frac{316}{5.5} = 57.5$ C. Hour

Proof:

310 × \$.007 = \$2.170
6 × \$.007 = .042
½ hr. miscellaneous = .210
Inspection Credits 32
C. = Std. 14 × .007 = .098
Net Credors 18 × .007 = .126
\$2.646

Total wage = \$2.61
\$.007 × 25 per cent × 18 = .03 2.640
Error = \$ .006

8. Good parts inspected = 334 × 1.3 min. = 434 Credors made
Total parts rejected = 17 × 2.1 min. = 36
470 total Credors
False rejects = 15 × 4 min. = 60
410 net Credors made

Time in plant 6 hr. × 60 = 360 min.
Day work = 36 min.
First aid = 24 60 300 min. on standard
110 Premium Credors

$\frac{410 \times .10 \times 17}{3 \text{ per cent} \times 1{,}000} = \frac{697}{30} =$ 23 Inspection Credits
133 Premium Credors

Base rate = 48 cts. × 6 hr. = \$2.88 base wage

$\frac{\$.48}{60} \times 75 \text{ per cent} \times 133 =$ .80 premium earned

\$3.68 total wage

$\frac{410}{300} \times 60 = 82$ C. Hour

9. 2,940/3,000 = 98 per cent correct in his recommendations
Table 7, 98 per cent = 19 hourly Premium Credors
Table 8, \$3,500 = \$.0058 value of each Premium Credor

125 hr. × 19 × \$.0058 = \$13.78 premium money
130 hr. × 45 ct. base rate = 58.50 base wage
\$72.28 total monthly wage

10. $\frac{407}{450}$ = 90.4 per cent correct in his recommendations
Table 7, 90.4 per cent is less than the minimum and so no premium is made.

130 hr. × 45 ct. base rate = \$58.50 total monthly wage

Chapter XX

Chapter XX instructs you how to apply group systems on either the piecework or the premium-plan basis. Some disciples of time study stress the virtues of individual effort, whereas others firmly believe in the group-effort plan. Both methods are presented so that you may judge for yourself which plan is best suited to your industrial work.

In fact, throughout this primer we have endeavored to treat impartially of the two major systems: the piecework and the premium plans. If many of the chapters seem to lean toward premium principles, we can only say that the examples were given to bring out salient points of time-measurement principles that are best explained, perhaps, by references to premium plans, because they have as their genesis time instead of money. If you prefer to operate on the piecework basis, the various examples which are given for premium methods can be altered to a piecework basis.

CHAPTER XX

GROUP-PIECE AND PREMIUM PLANS

Wage-payment incentive plans based on group, rather than individual, effort, have found favor in the last two decades in large and small factories. These plans reward the collective accomplishments of selected groups of workers rather than the single accomplishment of each worker under an individual-effort incentive plan.

The group systems in use are fundamentally alike, the broad differences being that work is paid for upon the basis of time saved, by flat piecework prices, or by a combination of the two. Since this book discusses time-study procedure regardless of the plan in use, no attempt is made to discuss the favorable or unfavorable points of any particular system beyond saying that more latitude may be taken in the analysis and measurement of work under a group plan. By this it is meant that the law of averages prevails under group plans, because slow operators are offset by faster operators, tight standards are balanced by loose standards, etc. A few of the other time-study liberties that are permitted will be discussed in these pages.

The departmental work to be paid for by group plans may be placed in either of the two following classifications:

1. Repetitive work that is constantly performed in steady volume by a fixed number of operators.
2. Miscellaneous types of work in job lots where, because of the variety of the work rather than its fluctuating volume, frequent adjustments in the number of men are required.

As almost every plant has both the first and the second types of production in one or more of its departments, a group plan should be considered for its flexibility in meeting these situations. In addition, the plan should be easily understood and should reward the faster workers in proportion to their contribution to the quantity and quality that are produced, the pay periods should be as short as possible, and the older employees should be

assured of their jobs. Besides realizing economy of costs, the scheme should tend to promote loyalty between employers and employees.

When the proper group plan has been selected, the next step is to classify the work of each department into divisions to be handled by the various groups of men. This sometimes leads to a complete change in machinery or equipment layout in order that the classified work may be confined to sections where all of its operations are completed by a concentrated group of men. For example, in an automobile plant, the equipment to produce connecting rods is localized in one spot, the equipment to produce pistons in another, etc. These divisions of work and volume that are required are serviced by the number of men that the C. Standards specify for the combined operations.

The nature of the job before time study sometimes dictates the approximate number of men required per group. As a rule, the various groups should be kept relatively small because the larger the group, the more time allowance or man power is necessary to take care of the inertia that is present in a large group. Although a large group has a singleness of purpose, it is not so flexible as a small group of men. The minimum recommended is three men per group, whereas the maximum may run over 100 per group. In one well-known automobile factory in Michigan, there are about 400 men in one group assembling cars. This number of men would be considered as too many per group were it not for the fact that they complete their assembly duties on power-driven conveyors which automatically set the speed and therefore unify the efforts of all participants. The ideal number of men per group, if not mechanically paced, is between 10 and 20. Since this number of men is small enough to be confined in a reasonably small floor space, the men themselves are apt to know each other better, the key men can supervise their work more closely, and a better spirit of teamwork will prevail. Notwithstanding this, however, the completion of all operations for some given part may call for a much greater number of men than desired for a group.

Groups should contain every one in the department except the foreman, his assistant, and the inspectors. This means that setup men, sweepers, oilers, chip men, truckers, foreman's clerks, and others are built into the time allowances or piecework

prices according to their contributing efforts. In case some of these men are not 100 per cent busy in their service work to one group, they may be prorated over several other groups in the department or may participate in group earnings up to the extent of their indirect ability to help create extra earnings.

After the work to be grouped has been determined, each of the regular productive work operations is analyzed, timed, and rated and Credor Standards are built for them in the official way. If the production is constantly moving and the effect of each man's effort is immediately felt by the others, the time studies may have to be altered before their use. This is called "balancing cycles" and consists of equalizing the work of each man in the group so that he works no more or less than his fellow workers. To balance cycles is to subtract from or add to each cycle one or more incidental or regular elements of work so that each man's effort in the group is the same. For example, if 10 men are engaged in assembling radio units which pass their work stations at the rate of 30 units per hour, each man should be "loaded" or should have exactly 2 min. worth of work per unit. If this is not possible, then certain operators will have A.I.T. and should therefore be paid on a % N.W.T. basis.

A striking example of the effects of balancing cycles is cited in an aluminum foundry where six molders were continually preparing molds for truck crank cases. These molders consisted of two drag men, two cope men, one core setter and one cope finisher. The molding unit consisted of two air-operated jolt-roll-over machines positioned in tandem order and these were serviced by an overhead electric crane. The flasks were filled by hand shovels. The total work elements were as follows:

1. Roll machine.
2. Clean patterns.
3. Place six loose pieces and six gates.
4. Set one ram-up core.
5. Place two chills.
6. Move drag to machine.
7. Riddle sand in pattern and set 40 nails to secure mold.
8. Tuck sand around gates and place six chills.
9. Shovel in sand and pean.
10. Butt off flask and strike off.
11. Place bottom board and clamp.
12. Roll machine, clean track.

13. Move truck to machine and draw pattern.
14. Draw six loose pieces and six gates.
15. Set eight cores and two oil pipes.
16. Anchor cores with 12 nails.
17. Cover nail-heads and oil pipe with sand.
18. Blow sand from mold.
19. Spray mold with oil.
20. Move mold to floor.
21. Set one housing end-core.
22. Roll machine.
23. Clean pattern.
24. Place one ram-up core.
25. Crane-move cope to machine.
26. Place two pouring sprues and one riser.
27. Set 29 gaggers.
28. Shovel sand in flask.
29. Pean flask.
30. Repeat 28 and 29.
31. Fill flask and butt off.
32. Strike off, remove sprues.
33. Move board to flask and clamp.
34. Roll machine, clean track.
35. Move truck to flask, remove clamps, and draw.
36. Ream two sprues and one riser.
37. Punch one blind riser.
38. Blow sand from mold.
39. Sling and hoist cope, punch nine vents.
40. Roll cope, ream two sprues, and one riser.
41. Move cope to drag and close.
42. Place two pouring cups and one riser cup.
43. Place four clamps on mold.

This molding job had formerly operated under an old time allowance that had been set by the foundry superintendent. The average production that had been obtained was 26 crank cases per 9-hr. day. When this job had been measured under modern time-study methods, the same six men, using the same equipment, obtained an average of 68 crank cases per 9-hr., or 162 per cent increase over the old production.

Before making recommendations, the T.S.M. timed and rated the job as it had regularly been done. The cycles found for each of the six men were as indicated in Fig. 37. Note from the graph that the cycle of 20.8 min. per mold was controlled by the core setter. This man, who received an 80 rating for his work, set the pace for the old production.

After experimenting for a few days, the T.S.M. was able to relieve the core setter of 12.86 min. of work by adding it to the work of the other five men in the group. By this change, the cycle was cut down to 7.94 min. and none of the men had the A.I.T. that had been previously enjoyed by five of them under the old scheme where each man did only the work that was theoretically within the scope of his job title.

The principles of balancing cycles as illustrated by Fig. 37 should be used, whenever possible, to equalize the work elements of all participants in the group. If it is impossible to call for an equal amount of energy for each man in the group, then the % N.W.T. principle should be incorporated so that each man's

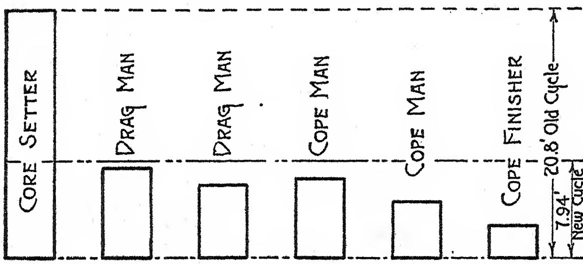


FIG. 37.—Graph covering a molding operation performed by a crew of six molders under a group arrangement where more production was obtained by balancing their individual work cycles properly.

earnings are directly proportionate to the actual amount of energy he exerts toward the creation of extra group earnings. As stated, the balancing of cycles is a much easier task where the members of a group are constantly completing their cycles on repetitive work of even volume.

To make possible the equalization of effort, it may be advisable to add items of work to a group which, from the standpoint of orthodoxy, seem to be out of place in the group. For example, the work of assembling automobile drive shafts in a plant that was placed on a group plan consisted of many so-called unrelated operations in order that the group men would not be idle when they were faced with delays, machine breakdowns, etc. To cut down the possibilities of check-out times, a group piecework price was allowed on the basis of all finished crated shafts that were placed in a railway car. Thus, the price was conditioned on drawing the raw or semifinished parts from the stock rooms,

assembling them completely, drawing lumber from the yard, making shipping crates, placing the shafts in the crates, and later placing them in the railway car. Not only was this an easy checking problem, but the 82 men in the group could always be kept busy without check-outs for minor delays to their regular work. Whenever something happened to the electric welding machines or to other tool equipment, the operators who were affected immediately began to make crates, to draw out more materials, to load box cars, to create subassemblies, or to do many other things to prevent the excess costs caused by the granting of check-out times.

In the foregoing case, the checking problem of recording the completed work was a simple expedient because the checker could see if each crate was properly filled and quickly count the total number of crates that were placed in the railway cars. Since the checker is a clerk who reports to the cost office, he does not share in group earnings.

The miscellaneous types of production, where quantity and combinations of unassembled and perhaps unrelated parts are made each day, present about the same kind of checking problems as those which are found under individual effort plans. Also, this type of production usually precludes the balancing of cycles because their C. Standards would have to be modified continually to balance the group effort according to the combination of parts that is being manufactured. Since this practice is prohibitive, the C. Standards for each job are built as for individual-effort plans and are merely added together as a lump sum for the work being performed by the assigned number of operators. Thus, each day the total Credor Group Standard varies as the combinations of work change.

The indirect workers who are to be incorporated in one or more groups are time-studied in the same manner as direct operators. The duties of the indirect workers are analyzed, timed, and rated and their Credor efforts are prorated over the C. Standards of the particular direct operations that they actually service. To illustrate this, we shall assume that the duties of a setup man are to be built into C. Standards. He is studied for a suitable period of time and his general duties are noted and timed. Let us assume further that the machines in one group cannot keep him fully occupied. Therefore, it is decided that he can service

during his 8-hr. day three groups of direct operators by an 80 effective effort on the various operations, as follows:

Group	Part	Operation No.	Machine used		Daily setup service, minutes	Per cent of day
			Name	No.		
1	1F17	3	Lathe	150	24	5.0
1	1F22	7	Turret	620	84	17.5
1	1G91	9	Lathe	151	36	7.5
2	2415	2	Miller	421	108	22.5
2	2716	2	Miller	422	108	22.5
3	190M	1	Drill	507	12	2.5
3	190M	2	Drill	510	72	15.0
3	190M	3	Grinder	717	36	7.5
					480	100.0

When the setup man's entire time has been allocated to the three groups, the next step is to build setup C. Standards for the operations which he services. Placing additional values on the above, we have:

A	*B*	*C*	*D*	*E*	*F*
Group	Part	Operation No.	Production per day @ 60 C. Hours	Setup minutes	Setup C. Std.
1	1F17	3	1,200	24	.02
1	1F22	7	600	84	.14
1	1G91	9	300	36	.12
2	2415	2	400	108	.27
2	2716	2	432	108	.25
3	190M	1	269	12	.045
3	190M	2	450	72	.16
3	190M	3	800	36	.045

The setup C. Standards in column *F* (found by dividing column *E* by column *D*) are then incorporated in the regular C. Standards for the parts specified in column *B*. If this is not desirable, the setup allowances can be recognized as miscellaneous items to be included at the end of the list of the regular C Standards, the sum of which is the total group C. Standard.

The same general figuration can be used for incorporating other indirect workers. In the case of janitors, the number of square feet of floor space per group might be used. Other indirect workers might be considered from the standpoint of the actual men per group that they assist. For example, the foreman's clerk, who is to share in the plan, may be taking care of the clerical work incidental to 75 men who are assigned to five different groups, as follows:

A Group	*B* Total direct and indirect workers	*C* Clerk service, per cent
1	10	13.3
2	12	16.0
3	25	33.3
4	18	24.0
5	10	13.3
	75	99.9

The percentage of the clerk's service to the total men (column *B* divided by 75) can then be converted to time or money and proportionately spread over each group's time allowance or piece-work price.

The truckers who move materials to and from various groups can be time-studied and their work incorporated in the different group allowances. The different kinds and styles of trucks should be classified and elements for each style should be set up as follows:

A. Move truck to job.	A focal point should be established and the average distance in feet should be found for the various stations covered. The average distance carries the proper normal time.
B. Load truck.	Establish average poundage or quantity per load and the normal time per average load.
C. Transport load.	Secure normal for the average distance traveled.
D. Return truck.	Secure normal for average distance between work stations and focal point.

By obtaining the time measurements of the various styles of trucks, the T.S.M. secures not only accurate data for immediate use but data which might also be used later if proposals are made regarding more economical means of material transportation.

In building up the total allowance for operators or for work to be grouped, the regular C. Standards are first listed, then at the end of the list are added the itemized time allowances for the various indirect workers who are to be embodied in the groups. In addition to these supplementary allowances, there may be other miscellaneous allowances to take care of a normal amount of scrap or reworking operations that are considered as manufacturing liabilities regardless of how careful or skilled the group men may be. One of the virtues of group plans is the minimizing of scrap because of the fact that each group operator acts as an unofficial inspector on the work that is received from a previous operation. Since only good work is paid for, each man endeavors to stop or correct improperly made work before he releases it to his co-workers. To make this unofficial inspection possible, extra time allowances may be necessary.

No extra time in group allowances should be granted for delays or check-out times that proper supervision can prevent. Many group allowances will be excessive if supervision requests, and is granted, extra time allowances to cover its own shortcomings. No matter how ideal manufacturing conditions may be, there are bound to be occasional delays that require check-out times. If time studies are correctly taken and if group allowances are carefully compiled, check-out times should be allowed, provided, of course, that the delays are beyond the control of the direct productive workers in the group.

Since check-out times result in tangible excess costs that higher management officials can properly criticize, the members of supervision often attempt to have many extra time allowances built into group standards in order to protect their own inefficiencies. A case of this kind is recalled in a plant where the constant pressure applied by the foremen resulted in the granting, in all group prices, of extra time allowances so liberal that nothing short of a cyclone would cause excess costs. This plant replaced its group system by an individual incentive plan, because the disciples of the latter were able to show that large savings would be caused by the substitution. What they actually did was

carefully to re-time-study each operation and to set up individual C. Standards that did not contain the previous erroneous allowances; then, by concentrating on the supervisors and other indirect workers, they were able to educate and train them to the degree of alertness necessary to prevent excess costs. Had the indirect workers demonstrated the same quality of alertness under the old group plan, it is doubtful if the new plan would have shown such large savings.

After the C. Standards have been built for each group and after the necessary indirect and miscellaneous time allowances have been added, the group time allowances are now ready for conversion to either premium or piecework systems. Therefore, the next step is to apply the incentives or wages to be earned by the various group members.

As previously mentioned in earlier chapters, the T.S.M. has no official part in the setting up of wages to be paid. However, he is usually invited to offer his comments regarding the relative weights of the rates as they apply to each operation. When he has been advised of the extremes of the base rates to be assigned, he is well qualified to suggest the proper ones to apply to each task because he has evaluated each task from the standpoint of effective effort.

Before piecework prices or hourly base rates can be prescribed, the management must determine what percentage of incentive is to be allowed. Since the group C. Standards are always conditioned on a normal status, the group men will be expected in due time to increase the production from a 60 to an 80 performance, or 33⅓ per cent increase. Since this spread makes an ideal incentive percentage, we shall, for the sake of consistency, use that percentage figure in the treatment of the principles that are to be outlined further in this chapter.

The same methods for establishing wage scales as were outlined in Chap. XV can be used for group work. In that chapter, several principles were given for the evaluation of the different tasks and the application of base rates to those tasks. It is believed that nothing more need be said about applying monetary values to the various operations or operators in each group except to deal briefly with the group leader.

Each group must have a key man or group leader who is a sort of a subforeman over the men with whom he is associated.

The group leader is selected not only because he is a skilled workman on the various group operations involved, but also because he possesses the qualities for inspiring the teamwork necessary for successful group operation. In view of the fact that the group leader also has regular productive work to perform and is the spokesman or means of contact between the management and operators, he should receive the highest base rate of any one in the group.

When the 80 C. Hour earnings have been established for each direct and indirect member of the group, the money values, based on 33⅓ per cent incentive, are then applied to the work of each participant. The next several pages will deal with the 33⅓ per cent incentives that apply to group piecework and premium work plans.

Table 9 shows the figuration of a group piecework plan for 38 direct operators who are assigned to the manufacture of a drop-forged part—2,000 of which are to be made in the 8-hr. department. The T.S.M. lists the 15 operations as indicated and against each he places the base rate and the Credor Cost as shown in columns *A* and *B*.

Column *C* carries the C. Standards for each operation as found by time study.

Column *D* shows the Credors that are required.

$$\text{Column } D = \text{column } C \times 2{,}000 \text{ forgings}^{1}$$

Column *E* shows the man power. Since each man is required to produce 80 Credors of work per hour or 640 Credors per 8 hr., it follows that the quotient which is found by dividing column *D* by 640 represents the man power required.[1]

Column *F* cost is found by multiplying column *B* by column *D*.[1]

Columns *C*, *D*, *E*, and *F* are then subtotaled as shown.

In building in the setup man, who is also the group leader, he contributes an effective 80 performance; therefore, his full service of 8 hr. (480 min.) must be converted to an 80 effectiveness by dividing the 480 by .75 = 640 contributed Credors. His base rate of 63 cts., or $.0105 Credor Cost, when multiplied by his contributing Credors per day, increases the group price by $6.72. The checking card for the group leader always calls

[1] Figuration does not apply to the four indirect workers as listed at the end of the table.

for 8 hr. on standard unless he is definitely checked out from participation in the group.

TABLE 9

Columns		*A*	*B*	*C*	*D*	*E*	*F*
Operation No.	Name of operation	Base rate, cents	Credor Cost	Credor Std., min.	Credors per 8 hr.	Men required	Cost of Credors
1	Bore and rough turn	45	$.0075	1.20	2,400	3.75	$ 18.00
2	Broach	42	.0070	1.30	2,600	4.06	18.20
3	Finish turn body	45	.0075	1.80	3,600	5.63	27.00
4	Rough mill	42	.0070	.60	1,200	1.88	8.40
5	Drill main holes	39	.0065	.74	1,480	2.31	9.62
6	Line ream	39	.0065	.54	1,080	1.69	7.02
7	Grind faces	48	.0080	1.90	3,800	5.94	30.40
8	Saw pads	39	.0065	.40	800	1.25	5.20
9	Burr main holes	36	.0060	.67	1,340	2.10	8.04
10	Finish turn bearing	45	.0075	.88	1,760	2.75	13.20
11	Rough counterbore	42	.0070	.60	1,200	1.88	8.40
12	Finish counterbore	45	.0075	.32	640	1.00	4.80
13	Rebroach	42	.0070	.41	820	1.28	5.74
14	Burr for inspection	36	.0060	.70	1,400	2.19	8.40
15	Wash twice	33	.0055	.11	220	.34	1.21
				12.17	24,340	38.05	$173.63
	Setup man	63	.0105		640	1.00	6.72
	Trucker	33	.0055		213	.33	1.17
						39.38	
	Janitor 1/90	30	.0050		280	.44	1.40
						39.82	
	Clerk 1/200	39	.0065		127	.20	.83
					25,600	40.02	$183.75

NOTE: In prescribing man power for operations 1 to 15, inclusive, as indicated by column *E*, do not allow more than 38 direct men. Also, the checking cards for the indirect workers should not show more hours on standard than are shown on page 406. To schedule more men for a group than called for by the requirements will lower the efficiency.

It is assumed that the trucker was actually time-studied and that at an 80 effective speed ⅓ of his time was required for the handling of 2,000 daily forgings. He contributes:

$$\frac{480 \times \frac{1}{3}}{.75} = 213 \text{ Credors during his } \frac{8 \text{ hr.}}{3} = 2.67 \text{ hr. on standard}$$

$$213 \times \$.0055 = \$1.17 \text{ cost of trucking}$$

His daily checking card for this group always shows 2.67 hr. on standard.

Since the janitor, who can service 90 men, has only 39.38 men, his service to the group is solved as follows:

$$\frac{1 \times 39.38 \times 480}{90 \times .75} = 280 \text{ Credors} \times \$.005 = \$1.40 \text{ cost}$$

$$\frac{39.38 \times 8 \text{ hr.}}{90} = 3.5 \text{ hr. on standard or } \frac{3.5}{8} = .44 \text{ janitors}$$

His daily checking card shows 3.5 hr. on standard.

The clerk handles 200 men in the whole department, but since he is only called upon to service 39.82 men in this particular group, his cost of clerkship is

$$\frac{1 \times 39.82 \times 480}{200 \times .75} = 127 \text{ Credors} \times \$.0065 = \$.83 \text{ clerk cost}$$

$$\frac{39.82 \times 8 \text{ hr.}}{.200} = 1.58 \text{ hr. on standard or } \frac{1.58}{8} = .2 \text{ clerks}$$

His daily checking card shows 1.58 hr. on standard.

The total of \$183.75 is converted to a group piecework price as follows:

$$\frac{\$183.75}{2{,}000} \times 100 = \$9.19 \text{ price per 100 completed forgings}$$

Continuing the figuration, we shall assume that all the 38 direct operators assigned to the forging production were on standard for 8 hr. each and that a quantity of 2,000 finished forgings was made during that time. The cost clerk then prepares a list showing the base rate and the basic daily wage for each man in the group. The left-hand section of the list shows the clerk's first figures as shown on page 406.

Since the allowed piecework price is \$.0919 per forging, the cost of the 2,000 forgings is 2000 × \$.0919 = \$183.80. This total cost is one of the two factors which are used to determine the efficiency of the group. The other one is the sum of the basic wages paid to each member. Thus,

$$\frac{\$183.80}{\$137.43} = 133\tfrac{1}{3} \text{ per cent efficiency for the group}$$

After finding the 133⅓ per cent efficiency, the cost clerk applies this percentage to each of the 42 participants. This is done by multiplying the base wages by the computed efficiency factor, the products of which are the extensions shown at the right-hand section of the list. The sum, \$183.24, is within 51 cts. of the \$183.75 group price that had been established for the

Man	Base rate, cents	Hours on standard	Base wage	Actual efficiency, per cent	Total wage
1	33	8	$2.64	133⅓	$3.52
2	36	8	2.88	133⅓	3.84
3	36	8	2.88	133⅓	3.84
4	36	8	2.88	133⅓	3.84
5	36	8	2.88	133⅓	3.84
6	39	8	3.12	133⅓	4.16
7	39	8	3.12	133⅓	4.16
8	39	8	3.12	133⅓	4.16
9	39	8	3.12	133⅓	4.16
10	39	8	3.12	133⅓	4.16
11	42	8	3.36	133⅓	4.48
12	42	8	3.36	133⅓	4.48
13	42	8	3.36	133⅓	4.48
14	42	8	3.36	133⅓	4.48
15	42	8	3.36	133⅓	4.48
16	42	8	3.36	133⅓	4.48
17	42	8	3.36	133⅓	4.48
18	42	8	3.36	133⅓	4.48
19	42	8	3.36	133⅓	4.48
20	45	8	3.60	133⅓	4.80
21	45	8	3.60	133⅓	4.80
22	45	8	3.60	133⅓	4.80
23	45	8	3.60	133⅓	4.80
24	45	8	3.60	133⅓	4.80
25	45	8	3.60	133⅓	4.80
26	45	8	3.60	133⅓	4.80
27	45	8	3.60	133⅓	4.80
28	45	8	3.60	133⅓	4.80
29	45	8	3.60	133⅓	4.80
30	45	8	3.60	133⅓	4.80
31	45	8	3.60	133⅓	4.80
32	45	8	3.60	133⅓	4.80
33	48	8	3.84	133⅓	5.12
34	48	8	3.84	133⅓	5.12
35	48	8	3.84	133⅓	5.12
36	48	8	3.84	133⅓	5.12
37	48	8	3.84	133⅓	5.12
38	48	8	3.84	133⅓	5.12
Direct hr. on standard.......	..	304.00	$129.84	. ...	$173.12
Setup man................	63	8.00	5.04	133⅓	6.72
Trucker	33	2.67	.88	133⅓	1.17
Janitor....................	30	3.50	1.05	133⅓	1.40
Clerk......................	39	1.58	.62	133⅓	.83
Total hr. on standard......	..	319.75			
Total base wage...........	..	......	$137.43	Group earnings	$183.24

2,000 forgings in Table 9. This error is due to inability to schedule the exact man power specified in column *E*.

If it is desired to show the group Credor-hour performance in addition to the percentage of efficiency, this can be done as follows:

$$\frac{12.17 \text{ C. Std.} \times 2{,}000}{\text{hr. on Std.}} = \frac{24{,}340}{304} = 80 \text{ C. Hour}$$

One strong point of piecework plans, especially where the efficiencies are computed from money values, is that a predetermined production cost is obtained which cannot be exceeded unless check-out times are granted or incorrect man power is scheduled. On the other hand, a group piecework price must be altered periodically in order to conform to economic changes. Also, no group member can receive a base-rate increase without changing the group price. Since many plants are reluctant to make changes in their group prices, a wage increase granted to one group member must therefore be paid for at the expense of others.

The figuration for premium or bonus plans, where the incentives are computed on the basis of time saved, is slightly different from the methods used for piecework plans. To illustrate the difference, some of the data outlined in Table 9, together with the supplementary list of the cost clerk's data, will be used.

In Table 9, column *D*, a total of 25,600 Credors is specified for the equivalent of 40.02 men. These Credors, divided by their hours on standard converted to minutes, result in a quotient that is the efficiency factor.

$$\frac{25{,}600 \text{ Credors}}{319.75 \times 60} = \frac{25{,}600}{19{,}185} = 133\tfrac{1}{3} \text{ per cent}$$

After this efficiency factor has been used to increase the hours of each participant, the operators' earned times are multiplied by the base rates. For example, the No. 1 man in the cost clerk's list on page 406 receives the following figuration:

$$8 \text{ hr.} \times 1.333 \times 33 \text{ cts.} = \$3.52 \text{ total wage}$$

Another method of premium-plan figuration will be given.

Example.—An assembly job carries a 2-min. Credor group standard. Five men completely assemble 1,365 units in one day's time. On account of the nature of the work, only two of the men were on standard for 8 hr.; the other three were required to check out for service in other groups.

Solution.—The first step is to compute the Credors made and reduce them to hours:

$$\frac{1{,}365 \times 2\text{-min.}}{60} = 45.5 \text{ hr. allowed for job}$$

The total time spent by the five men on this job was 35 hr. Therefore,

$$\begin{array}{r} 45.5 \\ 35.0 \\ \hline 10.5 \end{array} \text{ hr. saved.} \qquad \frac{45.5}{35.0} = 130 \text{ per cent efficiency}$$

Each man is entitled to 30 per cent more time than he spent on the job. This is found as follows:

Man	Actual hours on standard	Extra hours earned	Total hours allowed
1	8.0 × 30% =	2.40	10.40
2	7.5 × 30% =	2.25	9.75
3	8.0 × 30% =	2.40	10.40
4	6.5 × 30% =	1.95	8.45
5	5.0 × 30% =	1.50	6.50
	35.0	10.50	45.50

The totals thus found should be in agreement with the checking-card data regarding hours on standard, extra hours earned, and the total Credors made, converted into hours.

When a new man is hired into a group, he usually receives a cheaper starting rate for 2 or 3 days, during which time the regular group operators enjoy the benefits of the new man's wage differential as part payment for their extra work in training him in his required duties. The group men do not like labor turnover in their groups and often assist the management in securing desirable men who are steady and consistent workers.

It will be noticed in group work that truckers, setup men, group leaders, janitors and other indirect workers will help the direct workers wherever and whenever possible so that more work will be produced and greater group earnings made.

If incentives other than 33⅓ per cent are advisable, the production as called for by the C. Standards can be converted to an 80 basis and the desired incentives applied accordingly.

Example.—A group piecework plan in a 6-hr. plant allows 50 per cent incentive for the anticipated daily output. A 45-ct. operator is to be

assigned to one of the manual operations which carries a 1.6-min. C. Std. per cycle. *Questions:*

a. What are the anticipated cycles per day?

b. After what daily quantity has been produced does the incentive become effective?

c. What is the piecework price per cycle?

d. What is the total daily wage for the anticipated performance?

Solution:

(*a*) $\dfrac{60 \text{ min.} \times 6 \text{ hr.}}{1.6 \text{ min.} \times .75 \text{ R.F.}} = \dfrac{360 \text{ min.}}{1.2 \text{ min.}} = 300$ cycles per day

(*b*) $\dfrac{300}{150 \text{ per cent}} = 200$ cycles before incentive starts

(*c*) $\dfrac{\$.45 \times 6}{200} = \dfrac{\$2.70}{200} = \$.0135$ piecework price per cycle

(*d*) $300 \times \$.0135 = \$4.05$ or $\$.45 \times 6 \times 150$ per cent $= \$4.05$ daily wage

The reader is cautioned against the use of figuration (*a*) for P.M.T. operations which have A.I.T. In cases of this kind, the cycles are determined from the combination of Externals and the P.M.T. as outlined on pages 170 and 171 in Chap. IX.

When a group is to be applied, the same general procedure as given in Chap. XVI is followed. In addition to the instructions and data imparted, the operators are told that they will be credited only for finished units or parts whose quality is acceptable to the final inspectors. The spirit of teamwork is stressed by pointing out the necessity of each man's inspecting the other fellow's work and lending assistance wherever possible to other group members so that the coordination of each man's enthusiastic and effective efforts will achieve success for all.

On the first page of this chapter, it was stated that more latitude may be taken in the analysis and measurement of work under a group plan. This statement should perhaps be modified to read, "More latitude is *usually taken* in the analysis and measurement of work under a group plan." In support of this statement, there are many large plants which require that their time-study men must time-study from 40 to 50 operations per 8-hr. day. For the sake of illustration, we shall assume that an average of 45 daily studies is demanded. On this basis, the T.S.M. must complete the analysis and measurement of an operation every 10⅔ min. It should be realized that by the time he has obtained the preliminary data, such as name of operator, operation information, feeds, speeds, list of all tools

that are used, and breakdown of all the operational elements, he has but little time left to do full justice to the standardization of each job. This is particularly true if the T.S.M. is studying different styles of machines which handle various kinds of operations.

To make up the obvious deficiencies in their time-study work, those pressure-applying plants use the time studies merely for a rough estimate of the production to be secured. Small arbitrarily granted allowances are added to the group piecework or the time allowances that are set up from the improper time studies, after which the direct group operators are first applied. When a short period of time has elapsed and the group begins to exceed the allowances, the indirect workers are gradually added to the group. It is at this point that the unfairness begins.

To compensate for the loose standards, the indirect workers are at suitable intervals added singly to the groups at time or money values considerably less than the actual values that should be allowed. By so doing, the members of the group are automatically cut. The cut, which amounts to the difference between the equitable value and the value that has actually been built into the group allowance, is suffered by all group members. For example, if a group is "doing too good," the management decides to tie in the trucker whose true contribution to the group would rightfully increase the group price by $1.20. If only $.90 is allowed for his participation, the group takes a cut of 30 cts. on their job. Should the group men soon overcome this handicap and begin to beat the anticipated efficiencies, other indirect workers, by the same unethical management practice, are added to the group by the "short-weight" method.

On account of the brevity or vagueness of the forms used by many factories to announce group prices or allowances, it is almost impossible for the average shop worker to compute accurately the correct additional allowance that should be added to a group standard to compensate for added members. This being true, the whole group, in spite of plant protestations to the contrary, is positive that some unfair practice is being indulged in even though they cannot check the degrees of unfairness.

Other plants which require high-pressure time-study work instruct their time-study men to snap a few cycles on each

operation and to convert the times found to terms of maximum production. In these cycle times are then included efficiency factors that are supposed to represent fatigue and all other allowances necessary for high-speed production. For example, the machine-shop efficiency factors of a large automobile plant for their various makes of machine tools are listed in Table 10:

TABLE 10

	Per Cent
Broaching machines	12 to 15
Boring mills	20 to 25
Horizontal drills	17 to 25
Radial drills	15 to 21
Multiple drills	23 to 25
Upright drills	15 to 20
Gear cutters	20 to 25
Grinders	17 to 25
Automatic lathes	24 to 25
Plain lathes	15 to 25
Turret lathes	15 to 25
Horizontal mills	15 to 24
Special large mills	24
Vertical mills	15 to 22
Punch presses	24
Threaders	20
Miscellaneous	10 to 25

The spread of the percentage ranges in the above table is supposed to compensate for the various manipulation differences of each make of machine. For one make of boring mill that is easily operated, a 20 per cent efficiency factor is specified. If the T.S.M. allowed 4.5 min. for a cycle requiring 80 or better performance, he increases that cycle by 20 per cent, or

$$4.5 \text{ min.} \times 1.20 = 5.4 \text{ allowed cycle.}$$

The 20 per cent coverage is allowed for all rest factors, material delays, tool trouble, and any other items that accompany boring-mill operation.

Efficiency factors similar to those outlined in Table 10 can perhaps be used for rough estimates of new work to be made but most assuredly should not be used when the T.S.M. is building regular C. Standards, whether for group or for individual incentive plans.

The plants which countenance the improper time-study practices that are described in the several foregoing paragraphs can never hope to enjoy a full spirit of loyalty on the part of their employees; neither can any plant secure the ultimate in production economy by leaving a group of workmen to their own devices in increasing the effectiveness of their joint endeavors.

Today, more than ever, correct time study is necessary. One large manufacturer has said that he has long since stopped looking for whole-penny savings—he is now intent on obtaining economies resulting from fractions of pennies saved on the various jobs in his plants. He is securing these fractional savings by using correct time study in the hands of trained time-study experts.

Problems

1. On page 408 in this chapter, the five men on the premium plan completed the assembly job in 35 hr. If each man had a base rate of 48 cts., what was the total of each man's wages for the 130 per cent earned efficiency, insofar as they applied to the assembly job in question?

2. The management officials, in setting up base rates for a group plan that allows 25 per cent incentive, decide that all men in one group should each make $2.70 per day of 6 hr. on standard in order to achieve the anticipated output. What is the common base rate granted to each group man?

3. The task of making 30,000 ash trays in each 6-hr. working day is to be placed on a group piecework plan. Using the basic data as given in the following table, complete the figuration. One-fourth trucker and one-fifth janitor will be allowed to the group. Show the supplementary figuration for these two latter men by converting their efforts to an 80 basis in the table.

Operation No.	Operation	Base rate, cents	C. Std. for one ash tray, minutes
1	Punch press.	36	.016
2	Punch press.	36	.032
3	Assemble base.	39	.056
4	Assemble holder.	39	.064
5	Straighten holder.	42	.080
6	Wash in tank.	27	.0096
7	Place in box.	30	.04
8	Fill carton.	30	.02
	¼ trucker.	30	
	⅕ janitor.	27	

What is the group piecework price per 100 ash trays? Show answer to two significant figures to the right of decimal point for all data in this problem.

Twenty-one direct men who worked whole or part time, completed 30,000 ash trays in 1 day. Using the basic data in the following list, determine their efficiency and show the earnings of all direct and indirect workers. The total wages paid should not exceed 1 ct. over the total piecework money for 30,000 ash trays.

Man	Base rate, cents	Hours on standard
1	36	6.0
2	36	6.0
3	36	6.0
4	39	5.8
5	39	6.0
6	39	5.6
7	39	5.7
8	39	6.0
9	39	5.8
10	39	6.0
11	39	5.8
12	42	6.0
13	42	6.0
14	42	6.0
15	42	5.8
16	45	6.0
17	27	3.8
18	30	6.0
19	30	6.0
20	30	5.4
21	30	5.8
Trucker	30	1.5
Janitor	27	1.2

4. Three molders are assigned molding jobs under a group plan as follows:

a. The first 48-ct. man, in 8 hr. on standard, produces 290 molds, each carrying a C. Standard of 2.4 min. per mold.

b. The second 45-ct. man, in 7.45 hr. on standard, produces 161 molds, each carrying 4 min. C. Standard per mold.

c. The third 54-ct. man, in 6.55 hr. on Standard, produces as follows:

20 molds, each carrying 6.4 min. C. Std. per mold
15 molds, each carrying 13.4 min. C. Std. per mold
49 molds, each carrying 5.0 min. C. Std. per mold

By use of one table, show the total Credors produced. By use of another table, show the total amount that was paid to each of the three molders on the basis of the group time saved on the jobs to which they were assigned.

5. Under a group plan, five men are operating machines that call for less than 100% N.W.T. The A.I.T. of each man, although paid at the base rate, is not subject to premium. The performances of the five men are as follows:

Man	Base rate, cents	Hours on standard			Parts made	C. Std., minutes	Credors made
		Actual	% N.W.T.	Allow			
1	45	8.0	90.0		115	5.0	
2	45	8.0	85.0		218	2.5	
3	42	8.0	95.0		155	4.0	
4	42	7.5	96.0		299	2.0	
5	48	8.0	82.5		279	1.9	

What is the efficiency?

In addition to the above figuration, compute the extra hours earned (show to two decimal places to right of decimal point) for each man, also compute his total daily wages. How many hours of A.I.T. did the plant charge to excess costs?

Answers to Problems

1.

Man	Actual hours on standard	Extra hours earned	Total hours allowed	Base rate, cents	Total wage
1	8.0 × 30% =	2.40	10.40	48	$ 4.99
2	7.5 × 30% =	2.25	9.75	48	4.68
3	8.0 × 30% =	2.40	10.40	48	4.99
4	6.5 × 30% =	1.95	8.45	48	4.06
5	5.0 × 30% =	1.50	6.50	48	3.12
	35.0	10.50	45.50		$21.84

2. $\frac{\$2.70 \text{ per day}}{6 \text{ hr.} \times 1.25} = \frac{2.70}{7.5} = \$.36$ base rate allowed

3.

Operation No.	Base rate, cents	Credor cost	C. Std.	Credors per 6 hr.	Men required	Cost of Credors
1	36	$.0060	.016	480	1.00	$ 2.88
2	36	.0060	.032	960	2.00	5.76
3	39	.0065	.056	1,680	3.50	10.92
4	39	.0065	.064	1,920	4.00	12.48
5	42	.0070	.080	2,400	5.00	16.80
6	27	.0045	.0096	288	.60	1.30
7	30	.0050	.040	1,200	2.50	6.00
8	30	.0050	.020	600	1.25	3.00
					19.85	$59.14
Trucker	30	.0050		120	.25	.60
Janitor	27	.0045		96	.20	.43
				9,744	20.30	$60.17

$\frac{\$60.17}{30{,}000} \times 100 = \$.20$ piecework price per 100 ash trays.

The trucker data were obtained as follows:

$$\frac{360 \times \frac{1}{4}}{.75} = 120 \text{ Credors}$$

$$6 \text{ hr.} \times .25 = 1.5 \text{ hr. on standard}$$

The janitor data were obtained as follows:

$$\frac{360 \times \frac{1}{5}}{.75} = 96 \text{ Credors} \qquad 6 \text{ hr.} \times .2 = 1.2 \text{ hr. on standard}$$

Man	Base rate, cents	Hours on standard	Base wage	Actual efficiency per cent	Total wage
1	36	6.0	$ 2.16	130	$ 2.81
2	36	6.0	2.16	130	2.81
3	36	6.0	2.16	130	2.81
4	39	5.8	2.26	130	2.94
5	39	6.0	2.34	130	3.04
6	39	5.6	2.18	130	2.83
7	39	5.7	2.22	130	2.89
8	39	6.0	2.34	130	3.04
9	39	5.8	2.26	130	2.94
10	39	6.0	2.34	130	3.04
11	39	5.8	2.26	130	2.94
12	42	6.0	2.52	130	3.28
13	42	6.0	2.52	130	3.28
14	42	6.0	2.52	130	3.28
15	42	5.8	2.44	130	3.17
16	45	6.0	2.70	130	3.51
17	27	3.8	1.03	130	1.34
18	30	6.0	1.80	130	2.34
19	30	6.0	1.80	130	2.34
20	30	5.4	1.62	130	2.11
21	30	5.8	1.74	130	2.26
			$45.37		$59.00
Trucker	30	1.5	.45	130	.59
Janitor	27	1.2	.32	130	.42
		Total base wage =	$46.14	Total wage =	$60.01

$$\frac{30{,}000 \times \$.002 = \$60.00}{\text{Total base wage} = \$46.14} = 130 \text{ per cent efficiency}$$

4.

Man	Molds made	C. Std. per mold, minutes	Credors made	Hours on standard
1	290	2.4	696	8.00
2	161	4.0	644	7.45
3	20	6.4	128	6.55
3	15	13.4	201	
3	49	5.0	245	
			1,914	22.00

$$\frac{1{,}914}{22 \times 60} = 145 \text{ per cent efficiency}$$

Man	Hours on Std.	Efficiency, per cent	Total hours allowed	Base rate, cents	Total wage
1	8.00	145	11.6	48	$ 5.57
2	7.45	145	10.8	45	4.86
3	6.55	145	9.5	54	5.13
			31.9		$15.56

5.

A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*J*	*K*	*L*
Man	Base rate, cents	Hours on standard			Parts made	C. Std., minutes	Credors made	Hours made		Total wage
		Actual	% N.W.T.	Allow				Extra	Total	
1	45	8.0	90.0	7.2	115	5.0	575	2.52	10.52	$ 4.73
2	45	8.0	85.0	6.8	218	2.5	545	2.38	10.38	4.67
3	42	8.0	95.0	7.6	155	4.0	620	2.66	10.66	4.48
4	42	7.5	96.0	7.2	299	2.0	598	2.52	10.02	4.21
5	48	8.0	82.5	6.6	279	1.9	530	2.31	10.31	4.95
		39.5		35.4			2,868	12.39	51.89	$23.04

$$\frac{\text{Column } H}{\text{Column } E \times 60} = \frac{2{,}868}{35.4 \times 60} = 135 \text{ per cent efficiency}$$

$$E = C \times D$$
$$J = .35 \times E$$
$$K = J + C$$
$$L = B \times K$$

39.5 = actual group hr. on standard
35.4 = allowed group hr. on standard
4.1 = hr. A.I.T. charged to excess costs

Chapter XXI

Setting up overhead rates is usually the job of the cost accountant. Modern time-study procedure recommends *factory* overhead rates which the foreman can control and for which he is alone responsible. To prescribe a general overhead rate for the foreman's use is to ask him to accept a cost budget containing items of expense about which he knows little or nothing.

An overhead rate should be split into two parts: one called *factory* overhead and the other known as *general* overhead. The latter is added by the cost accountant to manufacturing costs.

As stated in one of the earlier chapters, time study does not attempt to enter the field of cost accounting. It is believed, however, that, after the T.S.M. has selected the simplest type of figuration for obtaining standards and data that will best show operator performance, the cost methods used by the accountant should permit the time-study data to be received directly and without change when time values are converted into terms of cost. Thus, if there exists a close unity between the time-study and the cost departments, the work of the former is preserved in a continuous story from the time the checking cards are made out until the data are finally shown in cost statements.

CHAPTER XXI

SETTING UP OVERHEAD RATES

Factory accountants establish the general overhead rates to be used in the plant departments. These rates are based on the consideration of depreciation, taxes, insurance, rent, floor space, light, heat, power, supplies, maintenance, organization salaries, and other items of expense that may be set up as separate accounts. Among the items that make up overhead rates are items known as "fixed charges," such as depreciation, taxes, insurance, etc. These are definite factors for which yearly values can be specified. As many of the other items are subject to constant changes, they are estimated on the basis of past records or future trends.

The average foreman looks upon an overhead rate as some vague charge made to his department, a small part of which he believes is due to his own industrial conduct, whereas the other part is a charge against him for something that he knows very little about, or at least cannot control. Consequently, whenever the management reprimands him for his increasing overhead, the foreman is apt to wonder whether it is solely because of his own inefficiency or because the main office has been hiring more office stenographers.

In Chap. I the following definition was given:

> *Time study.*—A science covering the true measurement of time, as applied to industry, in which proper machine performance, methods, human endeavor, and conditions surrounding them are studied for the purpose of analysis and standardization.

So far as time-study work is concerned, this definition should also apply to indirect workers. In the foregoing chapters, the work of direct operators is reduced to the common denominator called a Credor. Likewise, the work of indirect workers should also be reduced to the same basis. By so doing, a direct means

of comparison from the standpoint of energy values will be provided between productive and nonproductive work.

As a result of splitting the general departmental overhead rate into two parts, the foreman is given one part known as "factory overhead," whereas the other part known as "general overhead," is later applied by the factory accountant.

If an overhead rate for factory use is conditioned on Credors, it offers a definite index for cost control insofar as effective effort is concerned. The more productive Credors produced, the more nonproductive Credors are required, or vice versa. Thus, the foreman is given a yardstick to control direct and indirect labor ratios for which he is held responsible. The effectiveness of his supervisory ability may be judged by his capacity to maintain economical labor cost ratios.

In setting up a factory overhead rate for the foreman, many things can be standardized. Among them are

1. The ratio of direct to indirect workers.
2. Number of indirect workers per given volume of production.
3. A basis for labor cost control.
4. A definite basis for supervision effectiveness.
5. A positive mathematical means of applying indirect incentives if desirable.

With reference to the fifth item above, many factories offer incentives to their indirect workers for their effective services which make possible the extra earnings that are enjoyed by the direct operators. If bonuses are granted to the indirect workers, the methods used should be made up of precise, mathematical factors that definitely fix the value of their contributing effectiveness.

Weekly, monthly, or yearly bonuses that are arbitrarily figured for indirect members by management officials after perusal of profit-and-loss statements or after reference to anticipated income tax returns are never satisfactory. The indirect employees are more desirous of giving their enthusiastic and unstinted support to a plan which rewards or penalizes them by a definite predetermined method. It is the purpose of this chapter to outline three methods of building factory overhead rates whether or not indirect bonuses are to be paid. The methods described apply to individual incentive plans because group plans have indirect effort embodied in the group C. Standards.

The first step of the T.S.M. in his approach to the fixation of factory overhead rates, is to make a list of all indirect work that is done in the department. By indirect work is meant all the tasks not covered by direct C. Standards. After the list has been completed, the various tasks are assigned to indirect job titles, such as foreman, assistant foreman, clerk, trucker, oiler, etc. The names of the particular individuals handling these tasks are not considered at this point.

Before any of the tasks are measured, each is analyzed. It must be determined how often per day each task is officially necessary. Some of the tasks may be of such nature and frequency that separate indirect C. Standards may be built for them. In these cases, the indirect workers who use these separate C. Standards can reflect individual Credor-hour performances. While so doing, they are not a part of the factory overhead rate and their hours spent on this repetitive indirect work are not contained in the overhead rate. Some of their tasks which bear separate indirect C. Standards may be classified as direct work; thus the indirect workers become partly direct and partly indirect workers.

On the other hand, perhaps some of the work that is performed by direct operators should rightfully be built into the overhead rates. For example, if 10 direct operators spend one half-hour each day in cleaning their machines, some plans require that, since each operator was not productively engaged all day, a total of 5 hr. should be built into the overhead rate as indirect work to compensate for each half-hour that the operators are off standard.

After the various indirect tasks have been assigned to individuals, it is often found that certain indirect workers have very little to do even before they are time-studied. A case of this kind is recalled in a foundry core room where the T.S.M. learned that the duties of a regular night man who was hired to watch the temperatures of the core ovens required only a fraction of a minute of the man's time once per hour to observe the recorded heats of the ovens and perhaps to make minor adjustments to the oven dampers and valves. The T.S.M. recommended that the night watchman, while paying his hourly visits each night to the core room, could easily handle this oven-attention job.

Thus, a man who was less than 5 per cent busy was transferred to a day time job where his full capacity was put to use.

If some of the indirect work is to be given separate C. Standards, the time measurements for the standards must be calculated as accuratēly as those for any productive operation. If the indirect work is to be built into factory overhead rates, a more liberal time-study policy may be used. These policies vary as the methods of building overhead rates vary.

Table 11 shows the data compiled for a factory overhead rate in a machine-shop department where the T.S.M. built the overhead rate on "as is" conditions, *i.e.*, he was advised that the indirect workers were all highly efficient and that an overhead rate should be conditioned on the existing setup of indirect man power.

Referring to Table 11, the T.S.M. first listed the foreman who works 30 hr., or 1,800 min. per week. Since some of his time is given to duties other than supervision, his weekly time for supervision, setup, inspection, and clerkship is split up into time intervals for these four classifications: 1460 min., 50 min., 240 min., and 50 min., respectively. The foreman's weekly salary is $61.20 or $2.04 per hour. Therefore, his Credor Cost is $.034. This Credor Cost, multiplied by the minutes of job classifications, yields the $49.64, $1.70, $8.16. and the $1.70 indirect costs as shown.

The one assistant foreman, in addition to handling four indirect classifications during his 1,800-min. week, also has 3 hr. or 180 min. per week which he utilizes for productive work. Thus, the assistant foreman becomes a 3-hr. direct operator each week. His base rate of $1.62 or $.027 Credor Cost creates a $4.86 productive cost each week.

The two inspectors, each receiving a 72-ct. base rate, spend their entire time of 1,800 × 2 = 3,600 min. on inspection work. The one additional inspector receives a base rate of 75 cts. per hour, hence his separate posting. The work of the three inspectors was considered too diversified to carry individual C. Standards for the inspection operations as outlined in Chap. XIX; consequently the three men are classed as regular indirect 30-hr.-a-week workers.

Although the two setup men could not keep accurate track of the time they spent on standard for productive work, never-

TABLE 11

No. of men	Job	Min. per week	Indirect classification					Direct cost			Indirect cost analysis				
			Supv.	Setup	Main.	Ins.	Clerk.	Min. on Std.	C. cost	Std. cost	Supv.	Setup	Main.	Ins.	Clerk.
1	Foreman	1,800	1,460	50		240	50		$.0340		$49.64	$ 1.70		$ 8.16	$ 1.70
1	Assistant	1,800	1,280	60	180		100	180	.0270	$ 4.86	34.56	1.62	$ 4.86		2.70
2	Inspector	3,600				3,600			.0120					43.20	
1	Inspector	1,800				1,800			.0125					22.50	
2	Setup man	3,600		3,300				300	.0115	3.45		37.95			
½	Oiler	900			900				.0075				6.75		
1	Janitor	1,800			1,800				.0055				9.90		
½	Clerk	900					900		.0065						5.85
9	Total	16,200	2,740	3,410	2,880	5,640	1,050	480		$ 8.31	$84.20	$41.27	$21.51	$73.86	$10.25
			Productive classification												
6	Lathe hand	10,800			300			10,500	$.0115	$ 120.75			$ 3.45		
4	Lathe hand	7,200			200			7,000	.0110	77.00			2.20		
5	Miller hand	9,000		180	250			8,570	.0110	94.27		$ 1.98	2.75		
2	Miller hand	3,600		180	100			3,320	.0105	34.86		1.89	1.05		
3	Planer hand	5,400		350	150			4,900	.0120	58.80		4.20	1.80		
5	Shaper hand	9,000			250			8,750	.0110	96.25			2.75		
4	Grinder hand	7,200			200			7,000	.0095	66.50			1.90		
3	Turret lathe hand	5,400		120	150			5,130	.0075	38.45		.90	1.13		
7	Drill hand	12,600			350			12,250	.0070	85.75			2.45		
2	Gear hand	3,600		130	100			3,370	.0095	32.02		1.24	.95		
4	Hand-miller hand	7,200			200			7,000	.0070	49.00			1.40		
7	Bench hand	12,600			350			12,250	.0110	134.75			3.85		
5	Bench hand	9,000			250			8,750	.0105	91.88			2.63		
2	Bench hand	3,600			100			3,500	.0100	35.00			1.00		
2	Tool grinder	3,600			100			3,500	.0080	28.00			.80		
5	Assembler	9,000			250			8,750	.0115	100.62			2.88		
3	Assembler	5,400			150			5,250	.0110	57.75			1.65		
3	Assembler	5,400			150			5,250	.0105	55.13			1.58		
2	Assembler	3,600			100			3,500	.0100	35.00			1.00		
75	Totals	133,200		960	3,700			128,540		$1,291.78		$10.21	$37.22		
84	Totals		2,740	4,370	6,580	5,640	1,050	129,020		$1,300.09	$84.20	$51.48	$58.73	$73.86	$10.25
		Base									Total indirect cost = $278.52				
	% Ratios	172,027	1.6%	2.5%	3.8%	3.3%	.61% = 11.81% total				$.049	$.030	$.034	$.043	$.006

theless, the records showed that they jointly produced a total of 400 productive weekly Credors. This total, when multiplied by the .75R.F. allows 300 min. on standard on the basis of an 80 performance.

The total of nine indirect men whose 16,200 weekly working min. are spread over the six subtotals also have the costs of the subtotals shown under the Direct and Indirect Cost Analysis sections.

Although each of the 75 direct operators is supposed to be in the plant for 30 hr. per week, none is on standard for 30 hr. Each operator is allowed 10 min. per day to clean his machine. Also, there are five machine classifications that require 960 min. of setup time per week. Thus, the direct operators become indirect workers each week for a period of $960 + 3{,}700 = 4{,}660$ min., which leaves only 128,540 min. on standard at a cost of $1,291.78 for their productive efforts. When the productive efforts of the indirect workers are included, the final totals show 129,020 min. or Credors produced at a total cost of $1,300.09. These last two figures are used to determine the standard cost per 100 Credors as follows:

$$\frac{\$1{,}300.09}{129020} \times 100 = \$1.007. \quad \text{Call \$1 standard cost per 100 Credors}$$

This standard cost is maintainable as long as all the direct workers can demonstrate 60, or better, Credor-hour performance. Check-out times, Credors to equal standard, etc., cause actual direct costs which will be higher than the standard direct costs.

The sum of the five Indirect Cost Analysis final totals is $278.52, which is the amount of money to be paid per week for all indirect work. In return for the expenditure of that indirect money, a certain productive performance is expected. The expected output is 80 performance. Therefore, the 129,020 min. on standard can be called Credors and converted to an 80 basis by multiplying by 80/60ths or by dividing by .75 as follows:

$$\frac{129{,}020 \times 80}{60} \text{ or } \frac{129{,}020}{.75} = 172{,}027 \text{ Credors}$$

When the 80 performance, for which proper service is expected from the allowed indirect personnel has been determined, the

next step is to obtain the standard indirect cost per 100 Credors, as follows:

$$\frac{\$278.52}{172{,}027} \times 100 = \$.162 \text{ standard indirect cost per 100 Credors}$$

The \$.162 standard indirect cost thus found is used for establishing the effectiveness of supervision as well as for a cost factor. More will be said later on in this chapter about the use of standard indirect costs.

In order to learn the ratio of indirect to direct work, the totals of the percentage ratios are shown. These are not entirely necessary but, if used, they offer an intelligent means of checking the indirect ratios between several overhead rates that are built for the various departments in the plant. For example, 2,740/172,027 = 1.6 per cent ratio of supervision minutes to productive minutes, which might compare favorably with the ratio of another shop or department.

After the make-up of the \$.162 standard indirect cost has been learned, by means of the same principle the money values can be used to obtain the standard cost per 100 Credors per classification of indirect work:

$$\begin{aligned}
\$84.20 \div 172{,}027 \times 100 &= \$.049 \text{ standard cost of supervision}\\
51.48 \div 172{,}027 \times 100 &= .030 \text{ standard cost of setups}\\
58.73 \div 172{,}027 \times 100 &= .034 \text{ standard cost of maintenance}\\
73.86 \div 172{,}207 \times 100 &= .043 \text{ standard cost of inspection}\\
10.25 \div 172{,}027 \times 100 &= \underline{.006} \text{ standard cost of clerkship}\\
\text{Total} &= \$.162
\end{aligned}$$

An overhead rate is the last application to be made in the department. It is very seldom applied until satisfactory Credor-hour performances have been obtained from the regular direct operators in the department.

A second method of building overhead rates, called the "ratio method," will be explained. This method deals with the numbers of men that indirect workers should properly service regardless of the actual personnel handled. For example, the foreman of a small department might supervise only 35 men although he is qualified to handle 70 men and, consequently, is only 50 per cent busy. From the standpoint of standard indirect costs, this foreman should be given more men to supervise or should work off 50 per cent of his time on productive work.

Premium is paid to direct operators for effective effort expended; likewise, if foremen are to receive bonuses for their supervisory work, the bonuses should be predicated on the effort that is required to supervise their departments properly.

A foreman who easily handles 150 men engaged in a rough class of work cannot be compared to one who is constantly busy on the task of supervising 25 men engaged in precision work that demands close supervision. In order to use the ratio method, the T.S.M. should have a broad background of experience before he can attempt to specify the correct number of men that a foreman can handle or that an indirect man can service. If the T.S.M. does not have the necessary background, he may be able to secure information from the general industrial field that will help him to prescribe ratios which are suitable for the peculiarities of the department in question.

Table 12 shows the data for building an overhead rate in a small department. No reference is made to the actual number of direct operators in the department. Instead, each indirect worker is assigned a ratio of direct 80 C. Hour operators whom he should be able to service if he himself demonstrates an 80 effective effort.

Table 12.—Ratio Method

Classification	Ratio	Total Credors	Base rate	Cost per 100 Credors
Foreman	1/75	6,000	$.93	$.01550
Assistant foreman	1/65	5,200	.84	.01615
Setup man	1/25	2,000	.63	.03150
Inspector	1/20	1,600	.72	.04500
Trucker	1/50	4,000	.45	.01125
Janitor	1/100	8,000	.33	.00413
Clerk	1/150	12,000	.45	.00375
Helper	1/12	960	.42	.04375
Errand boy	1/250	20,000	.30	.00150
				$.17253

Call $.173 standard indirect cost per 100 Credors.

In explanation of Table 12, the foreman, although handling a smaller number of men, should be able to supervise prop-

erly 75 men, each of whom is to be an 80 worker. Therefore, 75 men × 80 hourly Credors = 6,000 Credors per hour to be supervised. The foreman's base rate is 93 cts. per hour and, when it is divided by the 6,000 Credors, yields a quotient to be multiplied by 100. This results in the standard supervision cost per 100 Credors. The sum of all other indirect classification costs is the total standard indirect cost per 100 Credors.

The ratio method as outlined above can be used by the T.S.M. only after he has gained considerable time-study experience. Like the first method outlined in Table 11, the ratio method does not require actual time study. There are many times, however, when the T.S.M. cannot use the ratio method, particularly in certain textile mills where tradition dictates the ratio of indirect workers to direct workers even though it is apparent that the indirect workers are not "loaded."

Cases such as these that do not permit the ratio method can be taken care of by the "rated method," which requires a fairly close time measurement of each indirect worker to be included in the factory overhead rate. However, before any time studies are taken, the direct operations in the department should be showing a satisfactory stability that represents an average condition for the full or part attention of the indirect workers.

After the department settles down to an even basis, the T.S.M. time-studies and rates each indirect worker in the department. For example, he first studies the foreman on all his various regular duties of desk work, shop patrols, telephone conversations, maintenance of discipline, conference with inspectors, etc. These duties are then classified into items of supervision work and frequency, after which they are timed and rated. If this information cannot be secured in 1 day, the T.S.M. should obtain several days' observations on the foreman's job. The supervision work is to be reduced to the proper normal hours that are required to handle the job. If the foreman is in the shop for 8 hr. and the T.S.M. grants him a 50R. for his effective daily effort, the foreman's N.W.T. is 8 hr. × $^{50}\!/_{60}$ = 6.67 normal hours of work per day.

All other indirect workers to be built into the overhead rate are likewise time-studied and normal hours are established for their daily activities. Table 13 shows the application of the rated method to a department.

TABLE 13.—RATED METHOD

Job	Hours in department	Rating	Normal hours	80 hr. required	Base rate, cents	Cost per day
Foreman	8.0	45	6.00	4.50	93	$4.185
Assistant	8.0	65	8.67	6.50	84	5.460
Setup man	8.0	70	9.33	7.00	63	4.410
Setup man	8.0	50	6.67	5.00	63	3.150
Inspector	8.0	85	11.33	8.50	72	6.120
Inspector	6.0	80	8.00	6.00	75	4.500
Trucker	4.0	60	4.00	3.00	45	1.350
Janitor	5.0	40	3.33	2.50	33	.825
Clerk	4.0	75	5.00	3.75	45	1.688
Helper	7.5	60	7.50	5.63	42	2.365
Boy	3.5	55	3.21	2.41	30	.723
				54.79 Call 54.8 hr.		$34.776

In the above table, the foreman, although in the plant for 8 hr., was given a 45 rating for his supervisory work covering the present number of men under his direction. Normalizing his hours in the shop, the foreman could handle his job in 8 hr. $\times \frac{45}{60} = 6$ hr. actual N.W.T. The foreman's job is to bring up the production of each of his men to an 80 basis and, in so doing, he also should demonstrate an 80 effective effort. On this premise, if the foreman has only 6 hr. of daily work—at an 80, he can dispose of it in

$$6 \times .75 \text{ R.F.} = 4.5 \text{ hr.}$$

Therefore, the foreman is allowed only 4.5 hr. for his supervision work. The product of his base rate of 93 cts. and of 4.5 hr. is $4.185, which is the supervision cost per day. The same method of figuration is used for the other indirect workers.

Supplementing Table 13, let us assume that there are 50 direct operators in the department and that their Credor-hour performances for a period of several weeks show an average of 65 Credor Hour. Thus, 50 × 65 × 8 hr. = 26,000 productive Credors that are produced each day. The standard indirect cost per 100 Credors is solved as follows:

$$\frac{\text{Total indirect cost}}{\text{direct Credors}} \times 100 = \frac{\$34.776}{26,000} \times 100$$

$$= \$.134 \text{ standard indirect cost per 100 Credors}$$

The rated method also permits a factor to be set up which can be used to indicate the number of indirect hours required for each given number of Credors produced. The factor is obtained as follows:

$$\frac{54.8 \text{ hr.}}{26{,}000} = .00211 \text{ Standard Hour Factor per Credor produced}$$

Example.—Because of a slack season, the foreman has reduced his direct operators to a total of 35 men. Since each of these men is required to produce 80 Credors of work per hour, how many standard hours per day of supervision and other indirect service are necessary for the 35 men?

Solution:

$$35 \times 80 \times 8 \times .00211 = 47.3 \text{ standard indirect hours necessary}$$

The foreman should accordingly cut off $54.8 - 47.3 = 7.5$ hr. of indirect time to balance his direct personnel.

If, in the foregoing example, the foreman also had several day workers, their time in hours should be converted to Credors and added to the productive Credors before computing the standard hours. The expanded formula becomes

$$\text{Standard indirect hours} = (\text{hours day work} \times 60 + \text{Credors}) \times \text{hour factor}$$

Having established a factory overhead rate for a department by one of the three methods outlined in these pages, the foreman's effectiveness can also be reflected in a Supervision Credor Hour. This is accomplished by use of the Department C. Hour and the ratio of standard to actual indirect costs. Multiplying the Department C. Hour by the cost ratio yields a product known as Supervision C. Hour.

Example.—The average Credor-hour performance for all direct operators plus their check-out times, results in a 78 Department C. Hour for one week's work in a department. The standard indirect cost for that week is computed as \$296, whereas the actual indirect cost is found to be \$315. What is the Supervision C. Hour?

Solution:

$$\frac{\$296}{\$315} \times 78 = 94 \text{ per cent} \times 78 = 73.3 \text{ Supervision C. Hour}$$

A more accurate method of obtaining the cost ratio is by use of the following formula:

$$\text{Cost ratio} = \frac{A + B}{C + D}$$

where A = standard direct cost per 100 Credors
B = standard indirect cost per 100 Credors
C = actual direct cost per 100 Credors
D = actual indirect cost per 100 Credors

The Supervision C. Hour is the true measure of the foreman's effectiveness and can be used as the means of mathematically determining bonuses to be paid. In order to accomplish this, a supervision base must be set up. This base is usually set at 60 C. Hour because direct operators are normal at that point and the foreman and his other indirect workers can therefore be arbitrarily granted an equivalent 60 for their normal status or base. According to this theory, the foreman and his indirect workers will be subject to bonuses if the Supervision C. Hour each week is above the established base. Applying this principle to the foregoing 73.3 Supervision C. Hour example, and assuming the foreman was in the plant for one week of 30 hr., how many Premium Credors did he earn for the week?

Solution:

73.3 Supervision C. Hour
60.0 base for supervision
13.3 × 30 hr. = 399 Premium Credors earned by foreman

Sometimes the base for supervision is modified to suit existing conditions in a department. Chapter XVII explained the granting of Credor Hour Bases for old employees. The fact that they cannot produce 60 Credors per hour should be recognized when a base for supervision is set up. The figuration for the supervision base will be outlined in the following example:

The foreman of a department has 42 direct operators, some of whom cannot produce 60 Credors of work per hour. His records of the men are:

2 elderly men who are each given 56 C.H.B.
3 elderly men who are each given 52 C.H.B.
35 regular men who are each given 60 C.H.B.
2 (average) learners, who receive 48 C.H.B.

What is the correct supervision base?

Solution:

Number of direct operators	C.H.B.	Credor hourly, production
2	56	112
3	52	156
35	60	2,100
2	48	96
42		2,464

$$\frac{2{,}464}{42} = 58.7. \quad \text{Call 59 supervision base.}$$

When ratio and rated methods are used in accordance with Tables 12 and 13, a supervision base is often modified to compensate for certain indirect work that direct operators perform. Reference to Table 11 indicates that the 75 direct operators were allowed 960 + 3,700 = 4,660 min. on indirect work and, consequently, were not on standard for 30 hr. per week. Since the ratio and rated methods do not embody such contingencies, the base for supervision can be altered to compensate for the indirect work that direct operators perform. The figuration for the supervision base is outlined in the following example:

The foreman of a department has 32 direct operators, some of whom are on Credor Hour Bases and all of whom are granted allowances for cleaning their machines, etc. The averages of indirect time per hour for the various direct operators are as follows:

Direct operators	C.H.B.	Productive minutes lost per hour	Net Credor production	Net C. Hour production
10	60	5	55	550
2	56	4	52	104
3	52	2	50	150
15	60	2	58	870
2	48	5	43	86
32				1,760

What is the correct supervision base?

Solution:

$$^{1760}\!/_{32} = 55 \text{ supervision base}$$

If bonuses are to be paid to indirect workers to stimulate their performances, it is a matter of management policy as to whether all indirect workers are to share in an indirect incentive plan. One management might contend that the department janitor should not participate in bonus earnings. Another may believe that the janitor, by his spirited attention to his job, helps to create for the direct operators a better working condition that is conducive to higher quality and greater output and that, therefore, he should be one of the participants. As we have previously stated, *all* departmental indirect workers are built into overhead rates whether or not they share in indirect bonuses. At least the important members of the indirect personnel should share in the plan, because this precludes the possibility that certain direct operators make more money than an indirect worker who not only services but perhaps supplies the major part of the brains required on the direct operator's job.

The bonuses which are paid to indirect workers accrue either from a special fund that is allowed by the management or from a fund that is created by the direct operators. One well-known plan allows the operator 75 per cent of the Credor Cost for his premium, whereas the other 25 per cent is set aside as a fund for the indirect workers. In the latter case, the Supervision Credor Hours must be in excess of the supervision base before the premium is paid. It is the 75% − 25% basis that was used in so many of the previous chapters.

Continuing the use of the 75% − 25% basis, the premium or bonus that is paid to the indirect workers who are included in the departmental overhead rate is computed from the following formula:

$$E = P \times R \times .75 \times H$$

where E = premium money earned
P = Premium Credors earned
(Supervision C. Hour minus supervision base)
R = Credor Cost
H = hours in plant

Exemplifying the use of the foregoing formula, we shall assume the Supervision C. Hour for one week is 78 C. Hour and that a setup man, carrying a 63-ct. base rate, has worked 30 hr. during the week. The base for supervision is 60. What is the extra money and what are the total wages that are earned by the setup man for his week's effort?

Solution:

$$
\begin{array}{rl}
 & 78 \text{ Supervision C. Hour} \\
 & \underline{60} \text{ base} \\
 & 18 = P = \text{Premium Credors earned} \\
18 \times \$.0105 \times .75 \times 30 = & \$\ \ 4.25 \text{ premium money earned} \\
\$.63 \times 30 \text{ hr.} \qquad = & \underline{\ \ 18.90} \text{ weekly base wage} \\
 & \$23.15 \text{ total wage for week}
\end{array}
$$

The foreman and other indirect workers are figured in the same manner by applying R and H values to their particular cases.

With further reference to the 75% – 25% plan, the 25 per cent fund created by the direct operators is ample for an indirect money budget, provided that the standard indirect cost is one-third, or less than, the standard direct cost, or 25%/75% = ⅓ ratio. According to page 427, the standard indirect cost is $.162, whereas the standard direct cost is $1 or about ⅙ ratio. This signalizes a very nice balance between productive and nonproductive costs. In fact, the one-third ratio offers a satisfactory gauge for measuring labor cost relations, *i.e.*, if the indirect cost is less than one-third of the direct cost, it cannot be said that the factory overhead is "top-heavy." Reducing the statements made in this paragraph to rules, we may say:

Where the 75%—25% premium basis is used, an ample indirect fund is created, provided that the standard indirect cost is one-third, or less than, the standard direct cost. In such cases, the fund is underabsorbed if the supervision effectiveness is less than 80 Supervision C. Hour.

If the cost ratio is greater than one-third, the fund is overabsorbed when 80 or less Supervision C. Hours are earned. In such cases, the indirect premium money must be drawn from a separate budget or drawn from underabsorbed departments. Another alternative is to reduce the participants to the point where the fund is self-supported.

In building factory overhead rates, it is advisable to consider foreman salaries and the base rates of other indirect workers on the 3-ct.–60 basis as outlined in Chap. XV. To this end,

base rates or salaries should be raised or lowered. If this is not advisable, the unchanged hourly wages can be used to arrive at the basic wages paid. Premium should be paid, however, on the basis of 3-ct.–60 base rates that may be lower than the actual hourly rates.

After a departmental overhead rate is once established, it should remain unchanged unless some major issue causes its modification. Whenever indirect workers are granted salary or base-rate increases, the overhead rate is not adjusted. Instead, the recipients of the increases are told that greater effectiveness is expected from their endeavors to counterbalance the increased indirect labor cost. Individual checking cards are turned in each day for all indirect workers.

Quality factors are often used to temper Supervision C. Hours before bonuses are paid. This involves setting up percentage factors covering the relation between gross work produced and final work accepted by the management. Thus, if the supervision effectiveness for one week is 80 C. Hour, but only 95 per cent of the work that is produced is passable, the adjusted basis is $80 \times .95 = 76$ Supervision C. Hour allowed to the indirect workers.

In previous chapters, we have discussed operators' and department C. Hour performances. In these pages, the principles of Supervision C. Hours are outlined. All three offer a definite means of measuring the results of departmental or plant productivity. If the manager of a shop is advised that one department shows a weekly performance of 80-80-80, he knows without consulting voluminous cost statements that the operators are efficient, that there are no direct excess costs, and that the foreman in charge has further controlled his job by keeping his actual indirect costs on a parity with the overhead rate that has been set up by the T.S.M.

Questions

1. On page 430 in this chapter, the 26,000 productive Credors were obtained by the product of men, Credor Hours, and time in plant. Why was 65 C. Hour used in this case instead of 80 C. Hour?

2. How is the Supervision C. Hour found?

3. Should all the indirect workers who are included in a department overhead rate share in an indirect incentive plan?

4. Assume that you were the manager of a plant and the cost office advised you that the consolidated figures for the whole plant, for a period of two months. were as follows:

Period	Operators' C. Hour	Department C. Hour	Supervision C. Hour
June	82	76	68
July	82	80	75

What would be your reaction to these figures? State briefly your comments.

Problems

5. You, as a T.S.M., are called upon to set up a factory overhead rate in a department producing a miscellaneous lot of parts. You decide to build the rate by the ratio method. While you were taking time studies on the direct operators, you were also quietly observing each of the indirect workers in the department and learned that none of them was very busy in their services to the present number of direct operators. Because of this observation, you are specifying ratios that are greater than the ones found. The following data cover the indirect workers in the department:

Base rate, cents	Classification	Number of direct operators you believe can be handled
72	Foreman	120
60	Setup man	30
57	Inspector	15
36	Chip man	90
27	Sweeper	90
42	Helper	10
48	Belt man	75

What is the standard indirect cost per 100 Credors? Show "call" cost to two places to right of decimal.

6. In another department, you, as a T.S.M., are to set up a factory overhead rate and are to use the rated method. After timing and rating all indirect workers in the department, your preliminary data are as follows:

Duty	Hours on job	Rating	Base rate, cents
Foreman	9.0	60	72
Setup man	9.0	65	60
Inspector	8.0	45	57
Chip man	5.2	75	36
Sweeper	9.0	50	27
Helper	9.0	55	42
Belt man	3.0	80	48

The listed ratings were conditioned on the service that the indirect workers rendered to 65 direct operators whose average 9-hr. daily performances for a period of three weeks showed 63.9 C. Hour. What is the standard indirect cost (shown to four decimal places) per 100 Credors? What is the standard hour factor per Credor? Show to five decimal places.

Shortly after you have built the overhead rate, the foreman is required to reduce his direct personnel from 65 to 45 men. If the hour factor is used, how many even hours is he allowed for a standard indirect setup of indirect man power per 9-hr. day for his remaining direct operators?

7. In a plant that operates 6 hr. a day, a foreman has 125 direct operators who work on productive C. Standards. In addition, he has 5 day workers who have not as yet been time-studied. The hour factor is .0015. How many standard indirect hours per day is the foreman allowed?

8. The cost-office records show that the direct operators produced 270,000 Credors and earned an average of 75 C. Hour for the week. The records also showed a total of 260 hr. that were allowed to them during that period for check-out times. The standard indirect cost per 100 Credors is $.15, but the foreman allowed too many indirect hours and as a result, his total actual indirect cost was $450. Based on these figures, what is the Supervision Credor Hour?

9. Build a supervision base from the following:

Number of Direct Operators	Credor-hour Base
24	60.0
2	52.5
4	45.0
2	51.5

10. A certain plant operates a premium plan where the indirect workers receive Premium Credors valued at 75 per cent of the Credor Cost. The trucker, who receives 42-ct. base rate, participates in the plan which specifies a supervision base of 60 for the particular department that he services. The other data are as follows:

$.90 = standard direct cost per 100 Credors
$1.06 = actual direct cost per 100 Credors
$.25 = standard indirect cost per 100 Credors
$.415 = actual indirect cost per 100 Credors
244,000 = Credors produced
3,115 = total direct hours on standard
285 = check-out hours

If the trucker works 40 hr. a week, what is his total week's wages?

Answers to Questions

1. According to Table 13, the various ratings that were given to the different indirect workers were conditioned on the 50 men whose performance averaged only 65 C. Hour. Had these men shown an average of 80 C. Hour (23.1 per cent higher) for the several weeks' period, the T.S.M. would have granted higher ratings to the indirect workers because the 50 men would have required more indirect service. Therefore, the indirect ratings were based on present direct operator performances and not on those which were anticipated.

2. The Supervision C. Hour is found by multiplying the Department C. Hour by the cost ratio. This ratio, by the preferable method, is found by dividing the sum of the standard direct and indirect costs by the sum of the actual direct and indirect costs. Since the Department C. Hour reconciles direct operators' performance with their check-out times and since the cost ratio embraces costs, it is obvious that the Supervision C. Hour covers both direct and indirect workers when it reflects the foreman's effectiveness.

3. The question of whether indirect workers should share in an indirect incentive plan is a matter of management policy. However, the joint opinion of the foreman and the T.S.M. should influence the management officials as to individual cases of participants. If the indirect workers are to receive extra earnings from funds created by direct workers, the management may be reluctant to include certain nonproductive workers, if by so doing, the indirect fund will be overabsorbed.

4. Assuming that I was the manager and that the statements for the two months were presented to me for comment, my reactions would be as follows:

> In June, the operators, as a result of conditions within their control, were able to average better than the anticipated 80 performance. Therefore, as a body of men, they must be earning satisfactory wages for their high efficiencies. Their wages would have been higher were it not for many hours of check-out times allowed to them as indicated by the 76 Department C. Hour. I would therefore feel that the foremen were not following the work closely in allowing a six-point difference between the two Credor-hour performances. As further evidence of the laxity of the foremen, the 68 Supervision C. Hour for June shows that they were not able to control their indirect costs properly.
>
> The July performance, however, was much better. It shows that, although the average operators' C. Hour is the same, nevertheless they made higher wages because the foremen were more aggressive in eliminating check-out times (hence, more hours on standard) as shown by the 80 Department C. Hour. The Supervision C. Hour of 75 indicates that the indirect costs are much better but not entirely satisfactory.
>
> As manager, I would frankly state my opinions to the foremen concerning the two months' performances and request that the following month's reports show an 80 Supervision C. Hour in all departments.

5.

Classification	Ratio	Total Credors	Base rate	Cost per 100 Credors
Foreman	1/120	9,600	$.72	$.00750
Setup man	1/30	2,400	.60	.02500
Inspector	1/15	1,200	.57	.04750
Chip man	1/90	7,200	.36	.00500
Sweeper	1/90	7,200	.27	.00375
Helper	1/10	800	.42	.05250
Belt man	1/75	6,000	.48	.00800
				$.14925

Call $.15 standard indirect cost per 100 Credors.

6.

Duty	Hours in dept.	Rating	Normal hours	80 C. Hours required	Base rate, cents	Cost per day
Foreman	9.0	60	9.00	6.75	72	$4.860
Setup man	9.0	65	9.75	7.31	60	4.386
Inspector	8.0	45	6.00	4.50	57	2.565
Chip man	5.2	75	6.50	4.88	36	1.757
Sweeper	9.0	50	7.50	5.63	27	1.520
Helper	9.0	55	8.25	6.19	42	2.600
Belt man	3.0	80	4.00	3.00	48	1.440
				38.26		$19.128

$$\frac{\$19.128 \times 100}{65 \times 63.9 \times 9} = \frac{\$1{,}912.80}{37{,}382} = \$.0512 \text{ standard indirect cost of 100 Credors}$$

$$\frac{38.26}{37{,}382} = .00102 \text{ standard hour factor per Credor produced}$$

$$45 \times 80 \times 9 \times .00102 = 33 \text{ standard hr. allowed per 9 hr.}$$

7. 125 direct operators × 6 hr. × 80 C. Hour = 60,000 Credors
5 day workers × 6 hr. × 60 C. Hour = 1,800 Credors
61,800 Credors

61,800 × .0015 = 92.7 standard indirect hr. allowed

8.

$$\frac{\text{Credors produced}}{\text{C. Hour}} = \text{hr. on standard} = \frac{270{,}000}{75} = 3{,}600 \text{ hr. on standard}$$

$$\frac{270{,}000}{3{,}600 + 260} = \frac{270{,}000}{3{,}860} = 70 \text{ Department C. Hour}$$

$$270{,}000 \times \$.0015 = \$405 \text{ standard indirect cost}$$

$$\frac{\$405 \text{ standard}}{\$450 \text{ actual}} = 90 \text{ per cent cost ratio}$$

$$70 \text{ Department C. Hour} \times .90 = 63.0 \text{ Supervision C. Hour}$$

9.

Number of Direct Operators	Credor Hour Base	Credor hourly production
24	60.0	1,440
2	52.5	105
4	45.0	180
2	51.5	103
32		1,828

$$\frac{1{,}828}{32} = 57 \text{ supervision base}$$

10.

$$\frac{.90 + .25}{1.06 + .415} = \frac{\$1.150}{\$1.475} = 78 \text{ per cent cost ratio}$$

$$\frac{244{,}000}{3{,}115 + 285} = \frac{244{,}000}{3{,}400} = 71.8 \text{ Department C. Hour}$$

$$71.8 \times .78 = 56 \text{ Supervision C. Hour}$$

Since the 56 Supervision C. Hour is less than the 60 supervision base, the trucker earned no premium. His wage for the week was

$$\$.42 \times 40 \text{ hr.} = \$16.80 \text{ total.}$$

Chapter XXII

The work of the T.S.M. can often be standardized to the degree where many time measurements are specified from compiled reference data.

In its treatment of time-study standardization, Chap. XXII should indicate the vast possibilities of reducing data to tables, formulas, curves, constants, etc. Throughout this primer it has been emphasized that time allowances and piecework prices cannot be based solely on actual watch readings. Judgment is the primary factor which underlies accurate time measurements, but judgment should be backed up by facts whenever possible in the establishment of standardized time-study information for industrial use.

CHAPTER XXII

TIME-STUDY STANDARDIZATION

This is the age of standardization. Almost every industry feels the pressure of price or quality competition. Machinery, materials, methods, and conditions surrounding them are constantly changing. Manufacturing practices that were ideal for last year's performances may be old-fashioned in today's industrial life, because of a constant process of refinement and standardization.

Time study, in many of its details, is also subject to standardization. This being true, the T.S.M. should constantly be accumulating data and making notes of particular studies which can be "boiled down" whenever his time permits. After standardization, these data take the form of tabulations, curves, charts, or mathematical formulas. These data not only ultimately correct many of the errors of time measurements by keeping them within the 5 per cent error limit but save many hours in building standards. Since machinery, materials, and methods are continually changing, standards must therefore be altered accordingly. Notwithstanding the industrial changes, many fundamental time-study work elements are not likely to be affected or, if affected, can perhaps be modified by basic factors that accurately and quickly adjust them to meet newly imposed conditions.

One of the dangers arising from too much use of standardized time-study data is the probability of the T.S.M.'s losing his contact in the shop. As stated in the first chapter, the desired make-up of a T.S.M. is 80 per cent contact and 20 per cent education. This four-to-one ratio would indicate that the most accurately prepared time studies mean nothing unless they can be sold to labor. This selling is done by the T.S.M. before and after applications are made. A group of workmen may be entirely satisfied with C. Standards today and complain about them tomorrow. Many things provoke complaints, chief among

them being the money angle. If operators are not satisfied with their daily wages, their resentment may be directed toward the equity of time measurements. The T.S.M. should be selling, and keeping sold, the question of time—not money. To do this, he must constantly keep in touch with shop conditions. His contact cannot be maintained from some remote location. His frequent contact with operators working with questionable time measurements will do more to prevent labor reaction than a T.S.M. who has the same workers operating with correct standards but who rarely visits his jobs after they have been applied. Therefore, the spare time gained by the use of standardized data should be devoted to contact.

If C. Standards are accurately made, the direct and indirect workers, after a period of time, are not primarily interested in how they were built. This period of time depends upon the T.S.M. While collecting his time-study data on the productive operations, he is advising the foreman and others that whenever official changes are made, the altered or new standards may be wholly or partly made up of data taken from reference sheets rather than from actual time-study observations.

One of the first things to be standardized is the wording of work elements. The chief of the time-study department might send two different time-study men to study the same job and, although their over-all normals may agree, it is doubtful if their elemental times for the job will be the same. This variance will be due to the scope of the elements as interpreted by each T.S.M.

It would therefore seem advisable first to group all machine or manual operations into classifications and then to set up official legends or descriptions of work elements which cover the job classifications. These legends should be made so clear that no doubt will exist as to the exact beginning and ending of each element. If the scope of each element is made clear, there will be little overlapping of watch readings as explained on page 111 in Chap. VI. Other pages in that chapter explain the proper length of elements and state that they may consist of several distinct subdivisions of work that are collectively recognized in the elements.

Let us take the question of measuring a shaft with micrometers. Chapter XIX page 377 shows an uncompleted table of normals

for different sizes of micrometers. Such a table should be made from one or more curves prepared from at least three subdivisions of an element reading, "Gauge work to blueprint size." Those subdivisions might be as follows:

a. Pick up micrometer and place on work.
b. Adjust micrometer to limits required.
c. Remove micrometer and lay down.

Subdivision (*a*) would require a curve covering the size of the micrometer and the distance that it was moved to the work. It would take longer to move the micrometer 5 ft. than to move it 1 ft. (*b*) would be conditioned on two things: size of the micrometer and the blueprint limits that were demanded. The curve for (*c*) might be the same as for (*a*), or perhaps a little shorter, since a micrometer can be pulled away from the gauged surface more quickly than it can be applied. The sum of the ordinates from the three curves would be the Allowed Normal for the "Gauge work to blueprint size" legend. Curves for (*a*) and (*c*) might show but little difference because of the customary proximity of gauges and work and therefore might be consolidated as constant instead of changeable elements and merely added to the changeables in (*b*).

The handling of cutting tools can be reduced to formulas or curves. For example, the T.S.M. may plot data covering the work of securing, grinding, and setting of lathe tools. The required information would be the varying distances the workers must walk to secure tools from tool cribs and to reach the grinding wheel; the size, shape, and alloy of tools; the proper time between tool grindings; the materials that must be machined; the setting of tools singly or in clusters; etc. These data might require many curves that individually recognize tools, materials, transportation, grinding, and setting. The data covering frequency of grinding may be established as separate information to be used in the Count Column on the Master Observation Sheet.

Although twist-drill manufacturers recommend feeds and speeds for their drills, many time-study men find it profitable to set up their own hand-feed drilling-time data on the various makes of drill presses and on the different materials that are used in the plant. The drilling-time data are secured by drilling 1-in.-thick test bars of the different kinds of materials that are

used. The foreman or a skilled drill-press operator is requested to drill holes in the bars at the prescribed speeds and with a hand pressure on the drill-press lever that is suitable for an 80 performance. The 80-performance hand pressure can be checked by determining the feed per revolution from the time, the work thickness, and the speed of drill. The feed which is thus found is compared to the feeds that are recommended by the machine-shop handbooks. If the feed agrees with the handbook data, it can be called an 80 demonstration. If not, it can be interpolated to that performance. After suitable tests have been run on the different materials with drills ranging from the smallest to the largest in the plant, the data are plotted on cross section paper. The ordinates obtained indicate the time required to drill 1 in. of thickness at a normal or 60 basis of effort for the various sizes of drills. Curves thus prepared are used only for H.M.T. drilling operations. Drills that are power-fed are P.M.T. elements and are not converted to the 60 basis.

Space does not permit the listing of the thousands of work elements that can be standardized. All, however, should be reduced to the basis of normal time per piece, area, shovelful, etc. Curves and formulas can be made for fatigue, setups, preparation work, machine data, trucking, cleaning, and other things too numerous to mention.

The acquisition of data occurs through existing time studies or through tests that might be conducted to secure the desired information. To authenticate the data, they must be analyzed, summarized, and rechecked to the point where they are not only accurate but acceptable to all concerned.

All standardized data for manual effort should be converted to the normal basis. Also, they should be classified as constant or changeable work elements with the possibility of their being either External or Internal items.

The data sheets which are used should be 8½ by 11 in. in size so that they can be filed in ring or post binders. No attempt will be made to suggest the make-up of the sheets beyond saying that not only should all the facts be presented but copious references should be made to the source of the facts if they have been received from supplementary sheets.

The well-known system of decimal numbering should be used for filing data sheets. The digits to the left of the decimal

points represent the general classifications of the data, whereas the right-hand digits indicate the sheet numbers of the details of the classifications. The numbers—unused and used—should be listed in a master book. The same book can be used for time-study numbers for Master Observation Sheets. An example of the use of the decimal system is as follows:

File

1. Automatic Screw Machines
   - 1.1 Setups
   - 1.2 Cleaning
   - 1.3 Tool grinding
   - 1.4 Fatigue
   - 1.5 Counts
   - 1.6 Incidentals
   - etc.
2. Belting
   - 2.1 Life of
   - 2.2 Horsepower
   - etc.
3. Bench work
   - 3.1 Filing
   - 3.2 Chipping
   - 3.3 Tapping
   - 3.35 Tapping through-holes
   - 3.36 Tapping blind holes
   - 3.365 Tap grinding
   - 3.4 Reaming
   - etc.

The decimal-numbering system not only facilitates the filing of data in office file cabinets in concentrated group classifications, but the decimal symbols are easily entered in small spaces such as the Reference Column on the Master Observation Sheet and elsewhere. The anticipated number of data sheets may be so large that a cross-reference scheme becomes necessary.

Many of the data sheets will contain curves. The sheets for this purpose are also the 8½-by-11-in. size of standard cross-section paper that is made up of squares, each of which is divided into 100 small squares. The left-hand or ordinate scale usually specifies the normal times for the work element. The bottom margin or the abscissa scale usually specifies the other factors of the data that, together with the ordinates, are represented by curves or diagonal converging lines in the body of the paper.

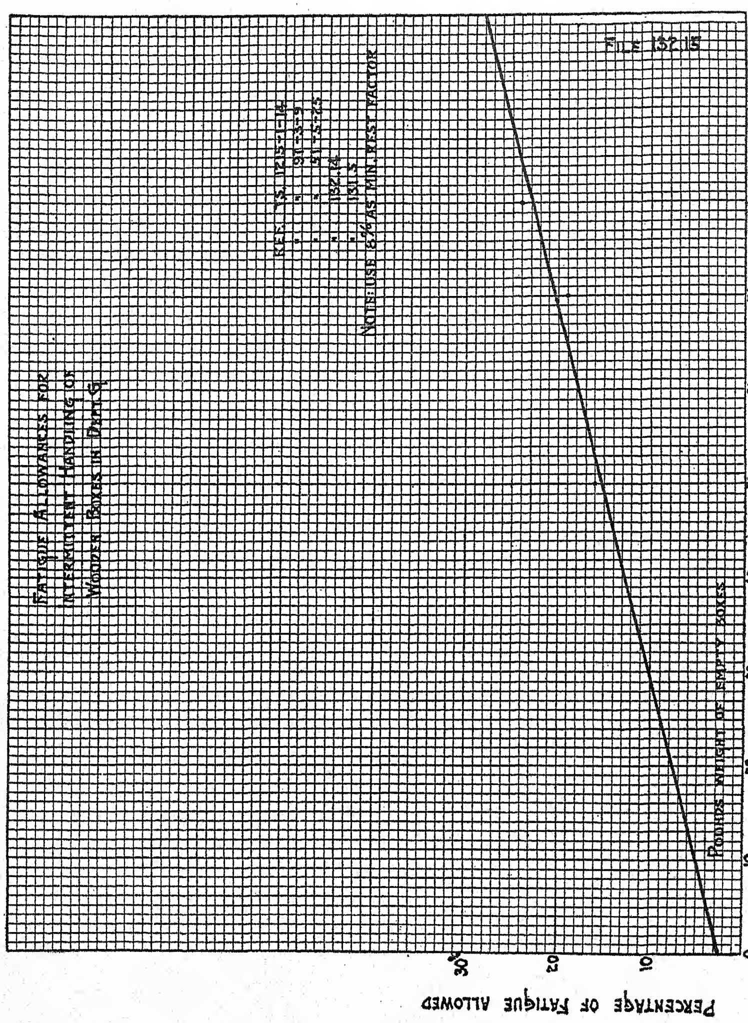


FIG. 38.—Rest factors allowed for handling empty boxes.

The use of curves eliminates a large amount of tedious arithmetic and formula derivation and should be used by the T.S.M. whenever it is possible to do so. It is assumed that the reader understands the fundamentals of curve building, so the basic principles will not be outlined. Should his standardization work require many odd types of curves, it is recommended that he purchase a textbook dealing with curve construction.

Figure 38 shows a curve that the T.S.M. prepared for the rest factors that were allowed for stacking empty boxes in a shipping storage room. He had previously plotted another curve covering the normals allowed for the various sizes and weights of the boxes that were being handled.

Referring to Fig. 38, the abscissa scale covers the different weights of boxes up to 100 lb. The ordinate scale shows the percentages of fatigue allowed. If boxes weighing 45 lb. are to be granted fatigue allowances, the T.S.M. finds the 45-lb. line on the lower scale and, at its vertical intersection with the diagonal line, locates the nearest intersecting horizontal line. At the left-hand end of this line is found 14 per cent, which is the rest factor specified for a 45-lb. box. Note that a minimum of 2½ per cent personal allowance is granted for an imaginary box of no weight and a maximum of 28 per cent for 100-lb. boxes. Note also that the sheet contains the time-study numbers and other reference numbers whose data contributed to the fixation of the ordinates.

An example will be given covering the steps that were taken to build a curve on the following problem:

An operator is being studied on the operation of grinding off burrs that are left on the ends of the steel studs made by automatic screw machines. One of the burring operator's work elements consists of walking a known distance for the studs which are in tote pans and then carrying them back to his grinding wheel. The T.S.M. secures normals for the proper time necessary to transport each pan to the burring station but finds that it will be a prolonged task on his part to count the exact number of studs of some given size in each pan. This information must be obtained for the Count Column on the Master Observation Sheet so that a normal handling time per stud can be established. The number of studs could have been secured from weighing scales but, since there were none near the job, the T.S.M. decided to figure the approximate contents of each tote pan on a size-factor basis. The small errors resulting from this method are scarcely noticeable in the Allowed Normal per stud.

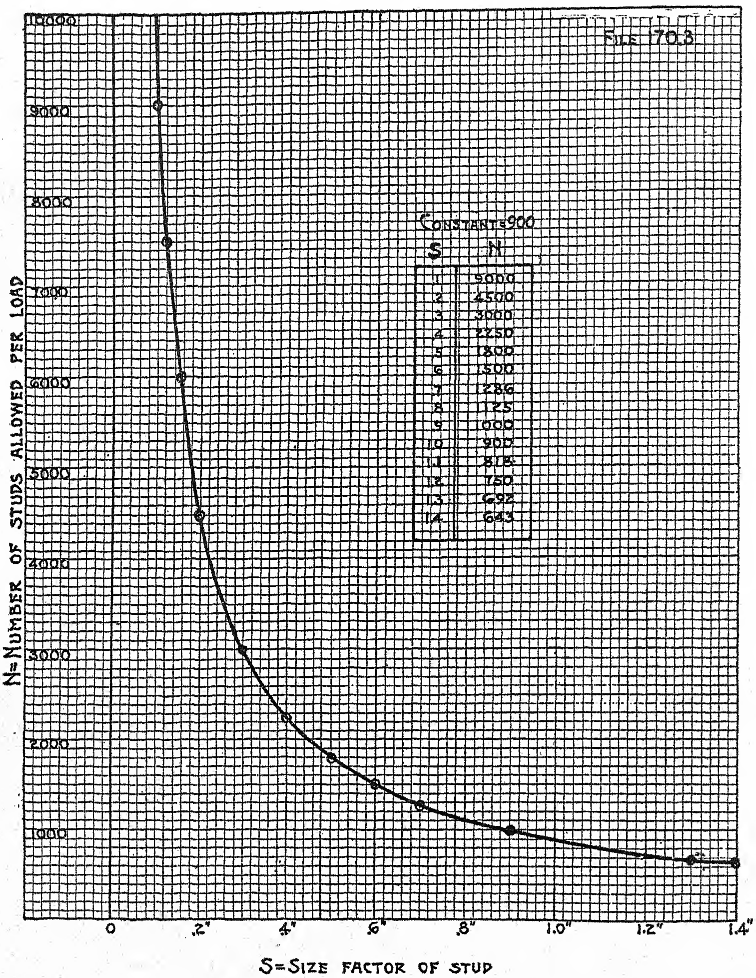


Fig. 39.—Curve covering different quantities of small pieces of work contained in a tote pan.

The T.S.M. first selected a tote pan containing an unknown quantity of the same sized studs, whose weight was satisfactory for convenient carrying. After both the foreman and operator had agreed that the weight to be carried was reasonable, the T.S.M. counted the studs in the pan and learned that there were 1,500 studs ½ by 1.2 in. long. Therefore, his figuration for the other stud sizes was based on the following formula:

$$N = \frac{G}{S}$$

where N = number of studs per allowed load
G = total size factors in load
S = size factor = diameter × length

The first step is to establish G, which is a constant that is used for all other stud sizes. It is obtained from the ½ by 1.2 in. size as follows:

$$S = \tfrac{1}{2} \times 1.2 = .6 \text{ in.}$$
$$G = .6 \times 1{,}500 \text{ studs} = 900 \text{ constant}$$

The T.S.M. next prepared a curve such as that illustrated by Fig. 39. On the bottom edge, he laid out the abscissa scale ranging from zero to 1.4 in. Along the left-hand side, he established a scale ranging from 0 to 10,000 to represent the quantities of studs per load.

Solving for N, the T.S.M. made a table in the body of the cross-section paper which showed his figuration for each size factor. For example, 900 divided by .2 size factor is 4,500 studs per load. After the N ordinates had been found according to the table, they were posted to the proper line intersections, after which he connected the points with a continuous line or curve as shown.

In using the curve, we shall assume that the T.S.M. seeks the count for the proper quantity of studs ¼ in. in diameter by 1.44 in. in length to be allowed per tote-pan load for comfortable carrying. The product of the

TABLE 14.—14 × 6 ENGINE LATHE

Element	Description	External or Internal	Formulas used for obtaining normal minutes
1.	Move work from can to machine table.	I	$.0133 + .00533W$
2.	Move work from table to centers......	E	$.027 + .00533W$
3.	Adjust centers and start lathe.........	E	$.0533 + .0027W$
4.	Set tool to size and engage feed.......	E	Use .08 min.
5.	Run back tool and stop lathe.........	E	$.027 + .0067L$
6.	Open centers and grasp work.........	E	$.027 + .0027W$
7.	Move work to machine table.........	E	$.027 + .00533W$
8.	Move work from machine table to can..	I	$.0133 + .00533W$
9.	Start lathe.........................	E	Use .025 min.
etc.			

diameter and length is the .36-in. size factor. By locating the .36 line on the S scale and then following it vertically to the curve intersection, we find a horizontal line, at the left-hand end of which is specified the quantity of 2,500 studs per load. Thus, a count of 1/2,500 is allowed per stud in carrying away the ¼-in. studs from the automatic screw machines to the burring operation.

Standardized data can be established for many of the regular work elements comprising the manipulation of engine lathes. Table 14 shows the formulas which are used to arrive at normal times for a few of the constant or changeable elements for a medium-sized engine lathe.

In the foregoing table, L is the length of tool travel in inches and W is the weight of the work in pounds. For example, in element 2, what is the Allowed Normal that is required to lift a 6-lb. shaft from a board at the rear end of the tail stock into the lathe centers?

Solution:

$$.027 + .00533 \times 6 = .059 \text{ min. N. allowed}$$

With reference to element 5, how much time is allowed to return the tool to the tail stock or starting position after turning a bearing 4 in. long?

Solution:

$$.027 + .0067 \times 4 = .054 \text{ min. N. allowed}$$

On the basis of the formulas in Table 14, curves can be prepared for the changeable of weight or tool travel, and thus the arithmetical work necessary for jobs of various weights can be avoided. Additional curves can be made for changing dogs, for oiling centers, for shifting tail stocks, and for many other items. Also, as different sizes of lathes are used, the formulas in Table 14 must be changed to compensate for the energy involved in handling larger or smaller lathes.

Table 15 illustrates a data sheet used for the summary of information covering the milling operation on drop forgings made in graduated sizes. This style of sheet shows the standardized element descriptions to be used, subelements, normals and reference-file numbers. The bottom of the sheet is reserved for notes that clarify or protect the data specified.

The use of curves is particularly desirable in reconciling C. Standards on graduated sizes of work that may have been built from actual time studies and not from standardized data similar

to those outlined in Table 15. A. T.S.M. is not infallible and may make mistakes when he is mentally tired. If the C. Standards for graduated work are plotted into curves on cross-section paper, any errors in the standards will be revealed.

It may require months or years to build up a complete set of standardized time-study information, especially if the T.S.M. has but little time to spend on the compilation of data. The data when completed is very valuable, not only for handling

TABLE 15

ROUGH-MILL BEARING PADS ON 14 SIZES OF TYPE H ANNEALED DROP FORGINGS

Use Style IF milling fixtures. Use Style T, B and S millers.

NOTE: All Master Observation Sheets should bear the following elements in the sequence given.

Element	Standardized elements	*E* or *I*	Reference file
A	Move forging from can to table.	*I*	72.70
B	Move forging from table to fixture.	*E*	72.80
C	Level and clamp forging in fixture.	*E*	10.15
D	Position table and engage feed.	*E*	12.10
E	Mill bearing pads to size. Specify blueprint limits	P.M.T.	12.37
F	Attention (based on element *E*).	*I*	33.90
G	Try gauge on preceding forging.	*I*	2.80
H	Return table to starting position.	*E*	12.20
I	Unclamp and away forging to table.	*E*	10.30
J	Away forging to truck shelf.	*I*	72.75
	Standard allowances		
	For ringing up lot card, allow 2.0 min. N.	*E*	
	For changing and adjusting cutters, allow 26.8 min. N.	*E*	
	For oiling and preparation	Both	1.26
	For fatigue	Both	92.40
	For setup time, allow 43.5 min. N.	*E*	

NOTES: For estimating purposes only, compute normals for elements to *J*, inclusive, and divide by .73 to obtain data for cost estimates.

Work to be inspected by traveling floor inspectors. Good forgings expected = 98.5 per cent.

See April 15, 19–, production performance that confirms C. Stds. for Part 203H and 205H forgings based on the above data.

repetitive work but also for building up synthetic C. Standards for nonrepetitive work.

Another valuable use of standardized time-study data is for the training of new time-study men. Not only are they thus given a set of definite instructions to follow, but their rating abilities are more quickly seasoned. Further practice will be obtained by time-studying various operators in the plant on certain applied operations and later comparing their normals with the standard normals allowed.

Questions

1. What is one of the dangers arising from too much use of standardized time-study data?

2. When formulas, tabulations, or curve ordinates for time measurements are used, why should the time elements be specified on a normal basis?

Problems

3. A curve, as per Fig. 40, is to be made for a milling operation for an element reading, "Move casting from machine table and place in fixture." There are many graduated sizes of castings of the same general design; each covered by a different part number. The casting weight varies for each individual part number.

On the basis of the formula $T = .027 + .00533W$, where T is the normal time in minutes and W is the casting weight, prepare a curve which specifies the normals that are allowed for castings of different weights. The following information is given for your guidance:

> Use Duplicate Fig. 40 in solving the problem.
>
> Use bottom side of Fig. 40 for normal-time ordinates. Establish a scale of ordinates ranging from 0 to .08 min.
>
> Use right-hand side as indicated for a scale of casting weights ranging from 0 to 10 lb.
>
> In explanation of the formula, the operator is allowed .027 min. to move his hand containing no castings from the end of the machine table to the milling fixture. Thus, the .027 is the constant part of the formula, whereas the $.00533W$ changeable takes care of the different casting weights that are handled.

Problem.—Based on the foregoing information, complete Duplicate Fig. 40, Prob. 3 by establishing the diagonal line properly on the cross-section paper so that the normal times allowed for castings of 10 lb. or less can be determined.

(*Continued on page* 459)

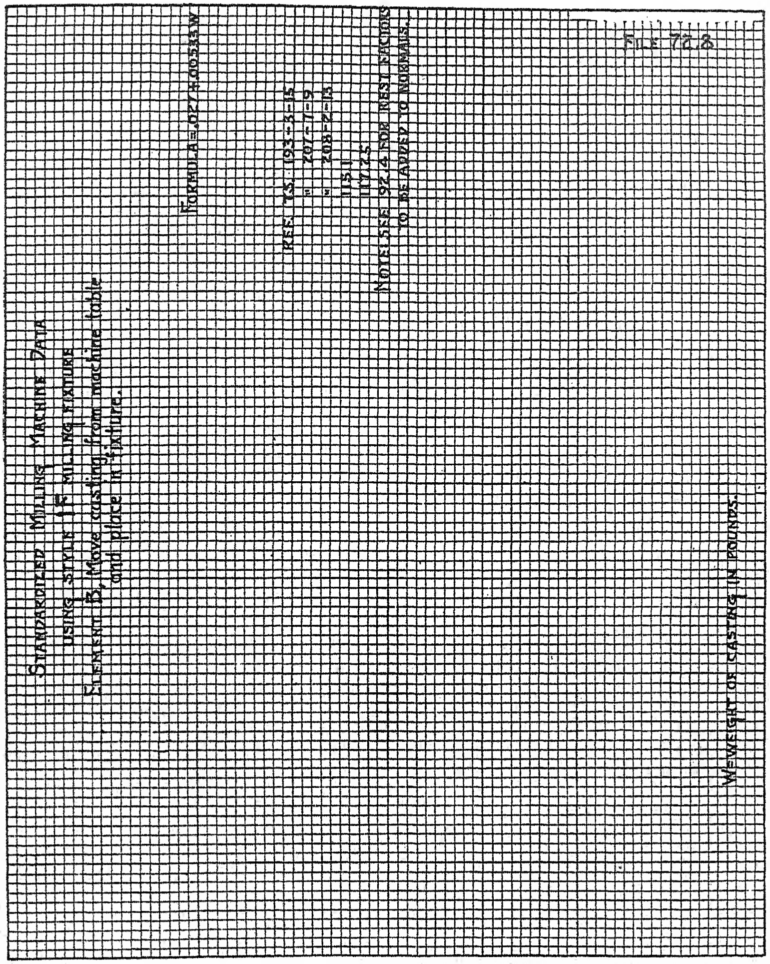
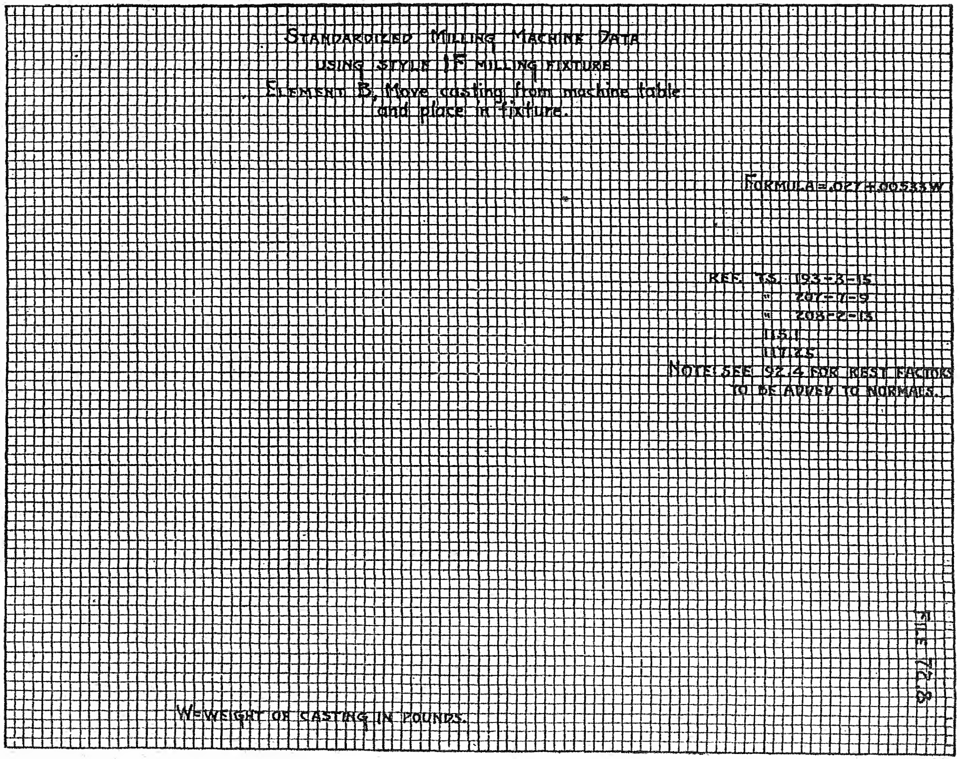


FIG. 40.—Unfinished curve-sheet relating to Prob. 3. Use the duplicate for figuration.



Duplicate FIG. 40.—To be used by the reader for the figuration of Prob. 3.

What is the normal allowed for a $2\frac{1}{2}$-lb. casting? Indicate by a small dot and circle the point of intersection for the $2\frac{1}{2}$-lb. casting on the diagonal line.

4. You, as a T.S.M., are called upon to build a Credor Standard for a lathe job in accordance with Fig. 41 which covers a partially completed Master Observation Sheet. Using Duplicate Fig. 41, Prob. 4, complete the figuration on the basis of the information that is given below:

Element		
A	Formula,	$.0133 + .00533W$
B	Use	.255 min. N.
C	Formula,	$.027 + .00533W$
D	Formula,	$.0533 + .0027W$
E	Use	.08 min. N.
F	Compute the P.M.T. from feed, r.p.m., and length of cut. Add 5 per cent for belt slippage. Review Chap. IX for figuration.	
G	Formula,	$.025 + .0067L$
H	Use	.08 min. N.
I	Compute same as for element *F* but allow only 3 per cent for belt slippage.	
J	Formula,	$.027 + .0067L$
K	Use	.16 min. N.
L	Formula,	$.027 + .0027W$
M	Formula,	$.027 + .00533W$
N	Formula,	$.0133 + .00533W$
O	The operator must be able to earn premium on his attention. Chapter XII explains normalizing attention.	
P	Allow	5.20 min. N. per tool grind
Q	Allow	1.88 min. N. per card change

The length of tool travel is indicated by L in the formula. W = weight of shaft in pounds. Use gross weight throughout figuration.

NOTES:

Elements *A*, *B*, *K*, *N*, and *O* are Internals.
Show 4 places to right of decimal point for normals.
Show 4 places to right of decimal point for P.M.T.
Show 4 places to right of decimal point for Allowed Normals.
Show 2 places to right of decimal point for C. Std.
Show 1 place to right of decimal point for % N.W.T.
Show 2 places to right of decimal point for machines run.

Questions:

a. What is the allowed C. Std. per shaft?
b. What is the production of shafts per hour?
c. What is the % N.W.T.?
d. How many machines can operator run?

(Continued on page 464)

THE BLANK CORPORATION
MASTER OBSERVATION SHEET

STUDY No. 1473

DEPT. NO. 2 DEPT. NAME LATHE DATE WRITTEN OCT. 3, 19–.

PART NO. 3P19 PART NAME PUMP SHAFT

OPERATION ROUGH TURN LONG BEARING END FOR GRINDER OPER. NO. 3

MATERIAL MACHINE STEEL $1\frac{1}{4}$ DIA. X 8" LONG. GROSS WEIGHT = 2.8 POUNDS. 150 SHAFTS PER CAN.

OPERATOR MALE ~~FEMALE~~ MALE STARTED 10-1-19–. STOPPED 10-1-19– ELAPSED $\frac{1}{2}$ HRS.

MACH. NO. 1517 MACH. NAME 14 X 6 LE BLOND LATHE

TOOLS TWO $1\frac{1}{2}$ BENT TAIL LATHE DOGS. ONE 2" MIKE. TWO #31T LATHE TOOLS. SPEED 365 RPM FEED .020" PER REV.

CREDOR STD. PER SHAFT %A.I.T. %N.W.T

ELEMENT	REFERENCE	DESCRIPTION OF ELEMENTS	NORMAL	REST	COUNT	ALLOWED EXTERNAL	ALLOWED INTERNAL
A	72.3	Move shaft from can to machine board.		9%			
B	72.6	Change dogs & white lead long end center.		12			
C	72.7	Move shaft from machine board to centers		9			
D	72.5	Adjust centers & start lathe.		8			
E	72.55	Set tool to size & engage feed for first cut.		12			
F	TS 1473-1-3	Take rough cut .893-.900 x $2\frac{1}{2}$ long.		–			
G	72.9	Run back tool.		10			
H	72.55	Set tool to size & engage feed.		12			
I	TS 1473-1-6	Take finish cut .758-.761 x $2\frac{1}{2}$ long.		–			
J	72.1	Run back tool & stop lathe.		10			
K	63.1	Measure every fourth shaft with mikes.		12			
L	72.56	Open centers & grasp shaft.		12			
M	72.3	Move shaft to machine board.		9			
N	72.33	Move shaft from machine board to truck.		9			
O	150.2	Attention 8% of elements F and I.		10			
P	72.75	Grind tool every 75 shafts.		10			
Q	16.7	Ring clock card every 150 shafts.		10			

REMARKS ABOVE C. STD. COMPUTED FROM STANDARDIZED DATA.

FOREMAN T.S.M. GEN. SUPT

FIG. 41.—Unfinished Master Observation Sheet relating to Prob. 4. Use the duplicate for figuration.

THE BLANK CORPORATION
MASTER OBSERVATION SHEET

STUDY No. 1473

DEPT. NO. 2 DEPT. NAME LATHE DATE WRITTEN OCT. 3, 19—.

PART NO. 3P19 PART NAME PUMP SHAFT

OPERATION ROUGH TURN LONG BEARING END FOR GRINDER OPER. NO. 3

MATERIAL MACHINE STEEL $1\frac{1}{4}$ DIA. X 8" LONG. GROSS WEIGHT = 2.8 POUNDS. 150 SHAFTS PER CAN.

OPERATOR MALE ~~FEMALE~~ MALE STARTED 10-1-19—. STOPPED 10-1-19— ELAPSED $\frac{1}{2}$ HRS.

MACH. NO. 1517 MACH. NAME 14 X 6 LE BLOND LATHE

TOOLS TWO $1\frac{1}{2}$ BENT TAIL LATHE DOGS. ONE 2" MIKE. TWO #31T LATHE TOOLS. SPEED 365 RPM FEED .020" PER REV.

CREDOR STD. PER SHAFT %A.I.T. %N.W.T.

ELEMENT	REFERENCE	DESCRIPTION OF ELEMENTS	NORMAL		REST	COUNT	ALLOWED EXTERNAL		ALLOWED INTERNAL	
A	72.3	Move shaft from can to machine board.			9%					
B	72.6	Change dogs & white lead long end center.			12					
C	72.7	Move shaft from machine board to centers			9					
D	72.5	Adjust centers & start lathe.			8					
E	72.55	Set tool to size & engage feed for first cut.			12					
F	TS 1473-1-3	Take rough cut .893"-.900" x $2\frac{1}{2}$" long.			—					
G	72.9	Run back tool.			10					
H	72.55	Set tool to size & engage feed.			12					
I	TS 1473-1-4	Take finish cut .758"-.761" x $2\frac{1}{2}$" long.			—					
J	72.1	Run back tool & stop lathe.			10					
K	63.1	Measure every fourth shaft with mikes.			12					
L	72.56	Open centers & grasp shaft.			12					
M	72.3	Move shaft to machine board.			9					
N	72.33	Move shaft from machine board to truck.			9					
O	150.2	Attention 8% of elements F and I.			10					
P	72.75	Grind tool every 75 shafts.			10					
Q	16.7	Ring clock card every 150 shafts.			10					

REMARKS ABOVE C. STD. COMPUTED FROM STANDARDIZED DATA.

FOREMAN T.S.M. GEN. SUPT

Duplicate FIG. 41.—To be used by the reader for the figuration of Prob. 4.

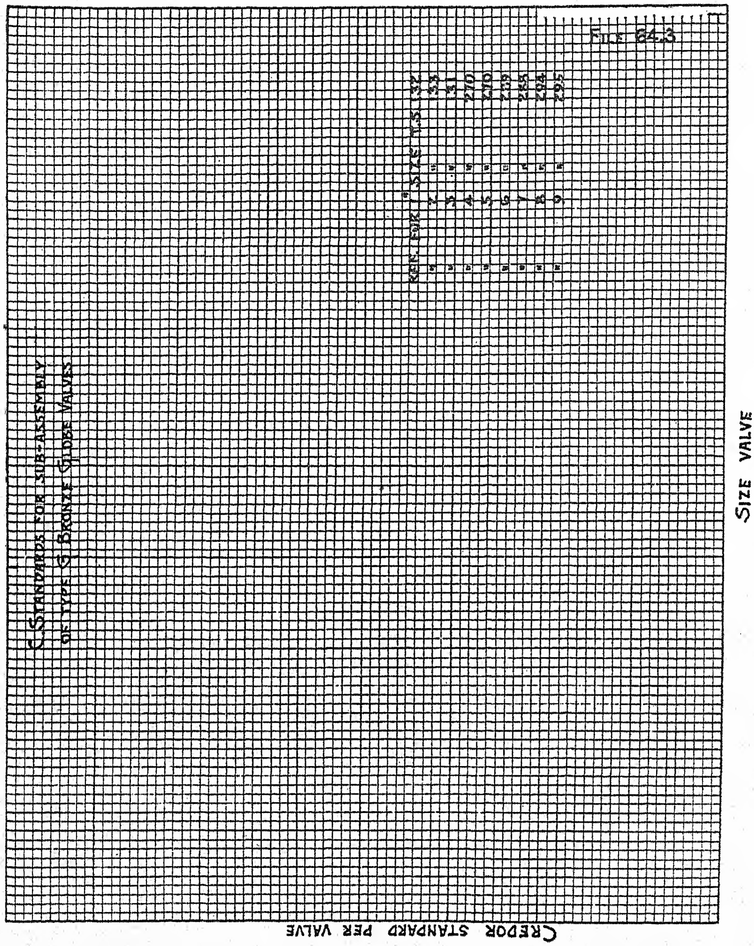
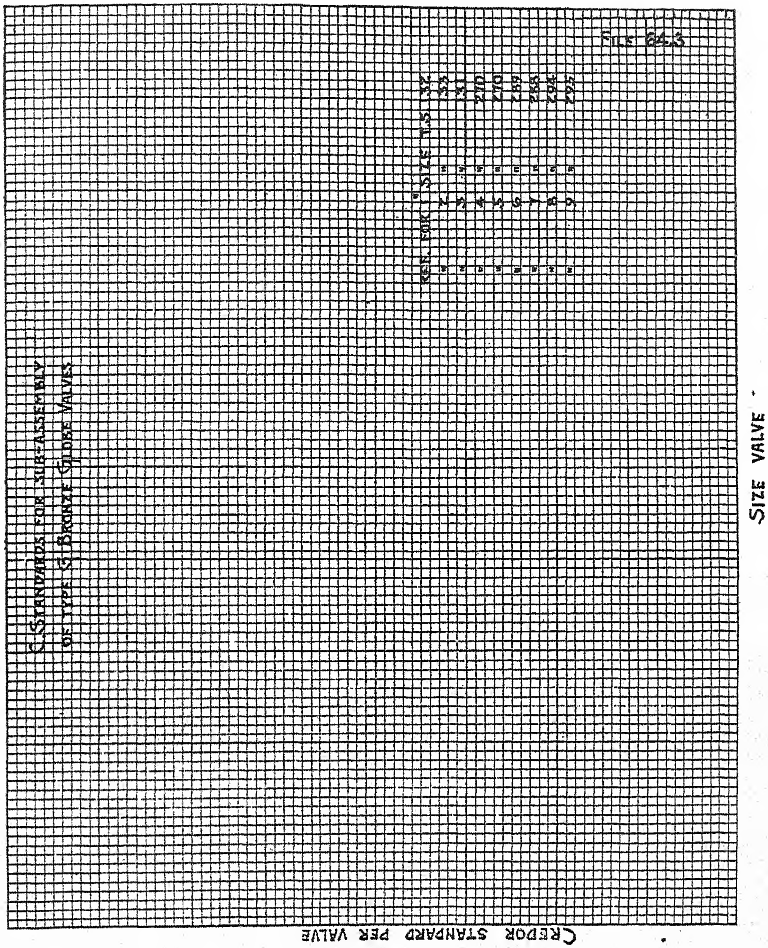


FIG. 42.—Unfinished curve-sheet relating to Prob. 5. Use the duplicate for figuration.



Duplicate FIG. 42.—To be used by the reader for the figuration of Prob. 5.

5. A T.S.M. built C. Standards covering a subassembly operation on some valves. Nine sizes of valves were individually time-studied and C. Standards were built for them as follows:

Size Valve, Inches	C. Std. Allowed Minutes
1	.8
2	1.4
3	2.0
4	2.8
5	3.2
6	3.8
7	4.4
8	5.0
9	5.6

After building the above C. Standards, the T.S.M. realized that, since the valve sizes were relative, the assembly work should also be relative. To prove his standards, he constructed a curve, the preliminary data for which are given in Fig. 42. After the curve had been completed, he found that one of the C. Standards that he had specified was in error.

Problem.—Using Duplicate Fig. 42, Prob. 5 construct a curve that is based on the sizes of valves as outlined and on the C. Standards specified. Indicate on the curve the C. Std. that is in error.

Answers to Questions

1. One of the dangers arising from too much use of standardized time-study data is the possibility that the T.S.M. will lose his contact in the shop. Unless the T.S.M. can maintain proper contact in the plant, his time studies, no matter how accurately specified, will not yield the fullest measure of success.

2. Formulas, tabulations, or curve ordinates are used to facilitate figuration or to assist in securing data. Throughout this book, we have recommended that the reader first reduce all time measurements for manual effort to the normal basis. Therefore, if standardized data for manual effort are always based on normal performance, they can be directly used for building C. Standards without supplementary figuration.

Answers to Problems

3. Figure 43 shows the completed curve. The small circle indicates .04 min. N. to be allowed for a 2.5-lb. casting, or, proved by the formula

$$T = .027 + .00533 \times 2.5 = .04 \text{ min. N.}$$

4. Figure 44 shows the completed figuration of the lathe job.

Element		
A	.0133 + .00533*W*	$= .0133 + .00533 \times 2.8 = .0282$ min. N.
B	Use .2550 min. N.	

Element		
C	$.027 + .00533W$	$= .027 + .00533 \times 2.8 = .0419$ min. N.
D	$.0533 + .0027W$	$= .0533 + .0027 \times 2.8 = .0609$ min. N.
E	Use .08 min. N.	
F	$\frac{2.5}{.020 \times 365} + 5$ per cent	$= \frac{2.5}{7.3} \times 1.05 = .3596$ min. P.M.T.
G	$.025 + .0067L$	$= .025 + .0067 \times 2.5 = .0418$ min. N.
H	Use .08 min. N.	
I	$\frac{2.5}{.020 \times 365} + 3$ per cent	$= \frac{2.5}{7.3} \times 1.03 = .3528$ min. P.M.T.
J	$.027 + .0067L$	$= .027 + .0067 \times 2.5 = .0438$ min. N.
K	Use .16 min. N.	
L	$.027 + .0027W$	$= .027 + .0027 \times 2.8 = .0346$ min. N.
M	Same as element C	$= .0419$ min. N.
N	Same as element A	$= .0282$ min. N.
O	$(.3596 + .3528) \times 8$ per cent	$= .7124 \times .08 = .0570$ min. N.

Since attention was calculated by the percentage method, it must be normalized as explained in Chap. XII. Thus,

$$.0570 \text{ min.} \times {}^{80}\!/_{60} = .0760 \text{ min. N.}$$

Operator can thereby make premium also on attention.

P Use 5.20 min. N. for 75 shafts.

Q Use 1.88 min. N. for 150 shafts.

Figure 44, Master Observation Sheet, shows the figuration as follows:

a. 1.03 min. allowed C. Std. per shaft.
b. 53 shafts per hour
c. 68.2% N.W.T.
d. 1.47 machines can be operated.

5. Figure 45 shows the completed curve; each valve size is represented by an ordinate that, with one exception, results in a straight line intersecting them. The exception is the 4-in. valve. The T.S.M., in specifying 2.8 min. C.Std. for the 4-in. valve, made an error of 2/10 of one Credor, because the curve indicates that the valve of that size carries a 2.6 min. C. Std.

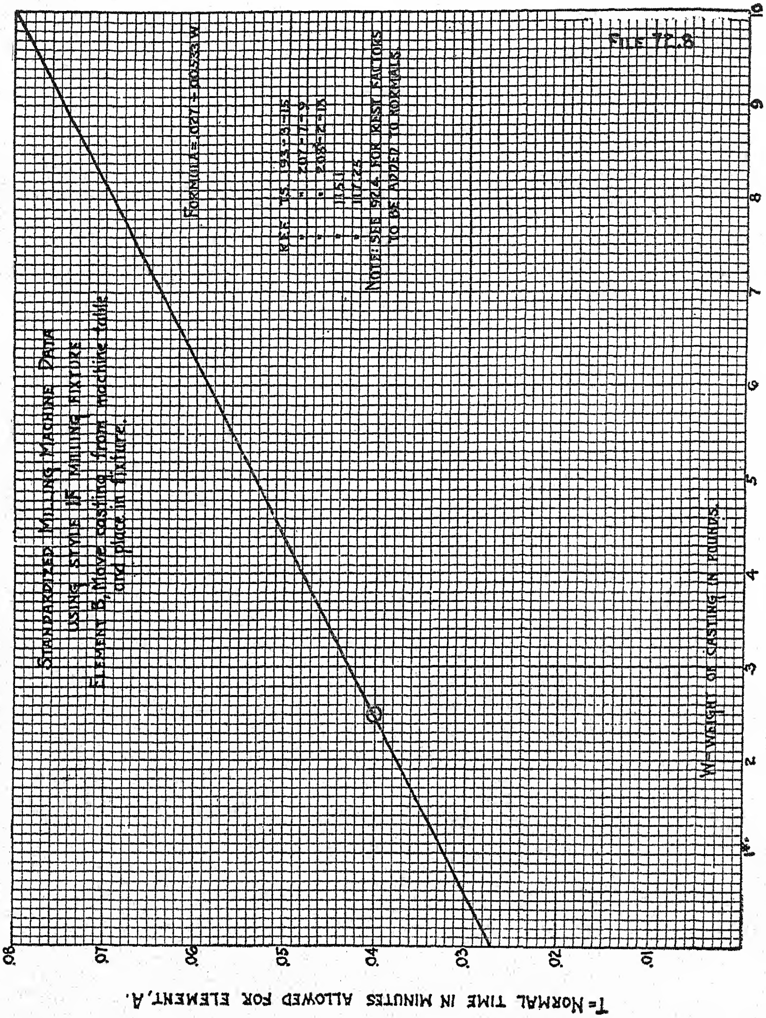


FIG. 43.—Showing completed figuration of Prob. 3.

THE BLANK CORPORATION

MASTER OBSERVATION SHEET

STUDY No. 1473

DEPT. NO. 2 DEPT. NAME LATHE DATE WRITTEN OCT. 3, 19–.

PART NO 3P19 PART NAME PUMP SHAFT

OPERATION ROUGH TURN LONG BEARING END FOR GRINDER. OPER. NO. 3

MATERIAL MACHINE STEEL $1\frac{1}{4}$" DIA. X 8' LONG. GROSS WEIGHT = 2.8 POUNDS. 150 SHAFTS PER CAN

OPERATOR MALE ~~FEMALE~~ MALE STARTED 10-1-19 – STOPPED 10-1-19 – ELAPSED $\frac{1}{2}$ HRS.

MACH. NO. 1517 MACH. NAME 14 X 6 LE BLOND LATHE.

TOOLS TWO $1\frac{1}{2}$ BENT TAIL LATHE DOGS. ONE 2" MIKE. TWO *31 T LATHE TOOLS.

SPEED 365 R.P.M.
FEED .020" PER REV.

CREDOR STD. 1.03 PER SHAFT %A.I.T. 31.8% %N.W.T. 68.2%

ELEMENT	REFERENCE	DESCRIPTION OF ELEMENTS	NORMAL	REST	COUNT	ALLOWED EXTERNAL	ALLOWED INTERNAL
A	72.3	Move shaft from can to machine board.	.0282	9%	1		.0307
B	72.6	Change dogs & white lead long end center.	.2550	12	1		.2856
C	72.7	Move shaft from machine board to centers	.0419	9	1	.0457	
D	72.5	Adjust centers & start lathe.	.0609	8	1	.0658	
E	72.55	Set tool to size & engage feed for first cut	.0800	12	1	.0896	
F	TS 1473-1-3	Take rough cut .893"-.900" x $2\frac{1}{2}$" long .3596' P.M.T.	–	–	1		
G	72.9	Run back tool.	.0418	10	1	.0460	
H	72.55	Set tool to size & engage feed.	.0800	12	1	.0896	
I	TS 1473-1-6	Take finish cut .758"-.761" x $2\frac{1}{2}$" long .3528' P.M.T.	–	–	1	–	–
J	72.1	Run back tool & stop lathe.	.0438	10	1	.0482	
K	63.1	Measure every fourth shaft with mikes.	.1600	12	$\frac{1}{4}$		.0448
L	72.56	Open centers & grasp shaft.	.0346	12	1	.0388	
M	72.3	Move shaft to machine board.	.0419	9	1	.0457	
N	72.33	Move shaft from machine board to truck.	.0282	9	1		.0307
O	150.2	Attention 8% of elements F and I.	.0760	10	–		.0836
P	72.75	Grind tool every 75 shafts.	5.2000	10	$\frac{1}{75}$	.0763	
Q	16.7	Ring clock card every 150 shafts.	1.8800	10	$\frac{1}{150}$	.0138	
						.5595	.4754
		Externals = .5595 x .75 RF = .4196					.5595
		Element F PMT = .3596	Call 1.03 C. Std.				1.0349
		" I " = .3528					
		1.1320' cycle					
		$\frac{60}{1.132}$ = 53.0 shafts per hour	$\frac{1.03 \times 53.0}{80}$ = 68.2% NWT				
		$\frac{1.00}{.682}$ = 1.47 machines run					

REMARKS Above C Std. computed from standardized data.

FOREMAN T.S.M GEN SUPT

FIG. 44.—Showing completed figuration of Prob. 4.

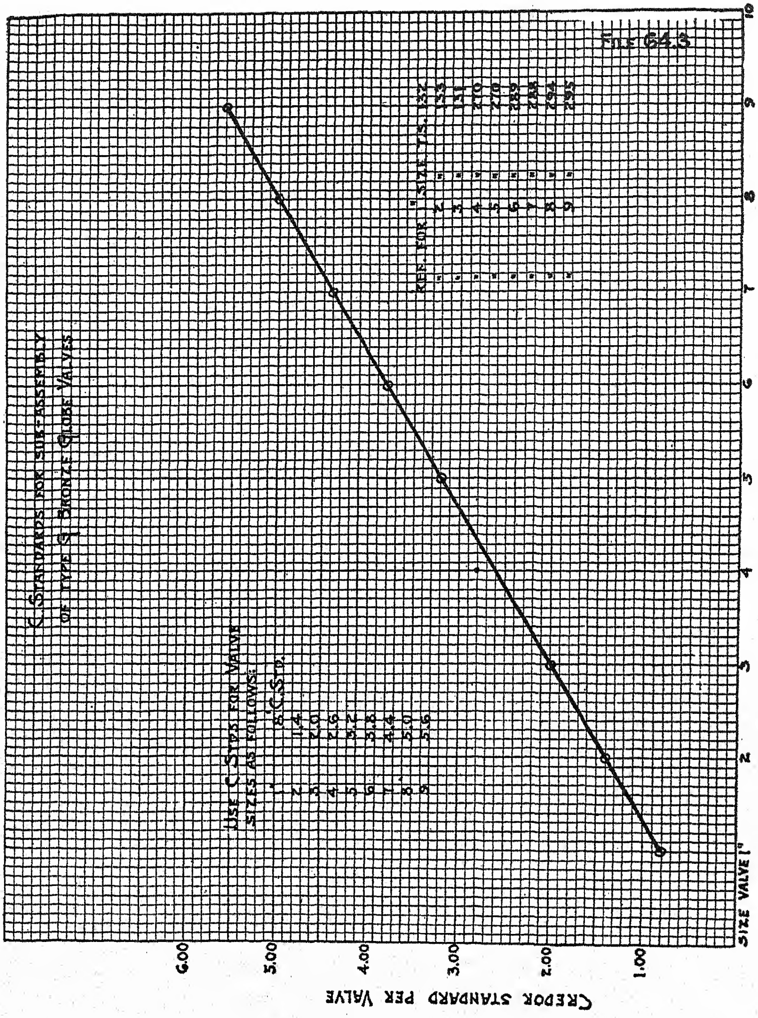


FIG. 45.—Showing completed figuration of Prob. 5.

Chapter XXIII

If one is to be regarded as an example worth emulating, one must not be like the old cobbler whose own shoes were always neglected because all his time was spent on the footwear of his customers. A T.S.M. will be more respected as a model of efficiency if he constantly practices efficiency in his own work.

The time-study department is a workshop and the cost and quality of its product depends largely upon the methods that are employed in it. Since the T.S.M. is one of the busiest men in the plant, his work is made easier if the details of it are handled in the best routine manner.

CHAPTER XXIII

ORGANIZING A TIME-STUDY DEPARTMENT

The outline herewith presented for the various steps to be taken in the organization of a time-study department will be based on the assumption that time-study work is something new to the plant. This hypothesis permits explanation of the elementary steps to be followed in the creation of the department. The reader can lightly pass over these fundamental steps if a satisfactorily operating time-study department is already in existence in the shop.

The initial step is to select a wage-payment incentive plan. There are many excellent systems in use throughout the United States, but, of course, some are less complicated and more flexible than others. Several different plans should be investigated and thoroughly studied before any final selection is made. The plan may be conditioned on piecework, on premium, on a combination of piecework and premium, or on some other system that is based on bonuses earned for the completion of specified tasks. The fundamentals of the selected plan might be conditioned on individual or on group effort.

When a suitable plan has been adopted and the higher management officials are definitely committed to it, one of the officials should be delegated as the sponsor or responsible agent for the plan. This official is usually the manager or general superintendent of the factory and is the immediate superior of the head of the time-study department. Although the head T.S.M., whom we shall call "time-study supervisor," has no choice in the matter, the appointment of his superior is a serious question. Time-study is such a revolutionary thing that it requires an official who not only is completely sympathetic with the work to be undertaken but who will stand squarely behind his time-study supervisor and support him in every decision that is made. If the time-study supervisor has a "weak sister" for his boss, the work will never bear the full fruit of success.

No matter how small the time-study department may be, all time-study matters should pass through the hands of the time-study supervisor in charge. Since he is responsible to his immediate superior, the time-study department should be located near the sponsoring official.

After establishing the location of the time-study department as a separate unit, the supervisor should submit to his superior a complete outline of time-study procedure to be followed. Such an outline will embrace:

Furniture and equipment needed.
Printed forms to be used.
Filing of work in cabinets.
Time-study work schedules.
Plant department to be first applied.
Establishing T. S. relations with shop.
Handling of labor reactions.
Expansion of time-study department.
etc.

Even though the plant is small and the time-study supervisor is the sole member of the personnel in his department, nevertheless a complete program should be submitted to his superior for endorsement. If a comprehensive plan of time-study-department procedure is worked out and approved, no basic changes need be made when the department is expanded to meet future manufacturing conditions.

The time-study office equipment consists of desks, tables, chairs, filing cabinets, stationery shelves, typewriters, adding or calculating machines, telephones, printed forms, slide rules, and other incidental equipment for these main items. The arrangement of equipment should be considered from the standpoint of efficiency.

The printed forms consist of

Shop Observation Sheets.
Master Observation Sheets.
Checking cards.[1]
Standardized Data Sheets.
Cross-section paper.
Premium Posting Sheets.[1]
Write-up or instruction sheets.
Scratch pads, etc.

[1] Later kept in cost office.

Time-study records are filed in office filing cabinets by several different methods. The most common method in use is to file studies by part numbers. All operations pertaining to some given part number are filed in a paper or fiber folder regardless of the plant departments producing the operations. Each folder in the file has the part number specified on its projecting tab.

A master book contains the used and unused time-study numbers assigned to each time study. The same book can be used for the decimal symbols that serve for the identification and filing of standardized data. These data should first be classified according to machine or work element. Cross references can be used for the filing of almost all time-study data. Some large time-study offices require the placing of a small printed slip in the folder of any data that are withdrawn from the files. This slip states the name of the person withdrawing the data and is removed when the material is returned to the files.

The time-study supervisor should submit to his superior a program covering the first factory department and the jobs to be time-studied. While it is highly desirable to make the time-study department self-supporting as quickly as possible by means of reductions in the cost of jobs that are susceptible to large savings, there are other things that have prior rights. As explained in earlier chapters, the first applications of time studies should be made on jobs where the foremen and operators are receptive to time study and where all other conditions promise early 80 C. Hours. The first successful applications do more to stimulate interest and enthusiasm than anything the T.S.M. can say. In view of this, the first time studies may not be taken on the jobs that will reflect the greatest tangible savings.

Because of the prodigious amount of detail connected with time-study work, all details should be subject to a fixed routine and should flow through the time-study department. There must be an arrangement to keep track of unfinished time studies. One way of keeping track of time-study data is to equip each desk or table with three-decked wooden or wire trays. Each of the trays is marked:

Bottom tray is marked "Jobs Ahead."
Middle tray is marked "In Process."
Top tray is marked "Finished."

It is sometimes highly profitable to have different time studies worked on by more than one member of the time-study department. For example, the T.S.M. can turn over his Shop Observation Sheets to a clerk in the time-study department who normalizes the watch readings. After this has been done, the studies are returned to the T.S.M. who indicates the proper normals to be allowed. The same clerk or a typist then prepares a long-hand line-up of the Master Observation Sheet which is again submitted to the T.S.M. The latter enters the rest factor to be granted for each element, after which the Master Observation Sheet is returned to the clerk for extensions, additions, and final C. Standard figuration. If the time-study department is large, several clerks can be trained to normalize the work flowing to their desks in progressive order, to select fatigue factors from standardized data, and to complete the final computations of the standards.

After standards have been built, both the T.S.M. and the time-study supervisor should check and initial the Master Observation Sheet. If a standard is compiled from standardized data, reference to the latter should be made before approval of the standard. If it is built from regular observations taken on the job, the completed standard should be confirmed by a spot check in the plant.

When C. Standards are finally approved by the time-study supervisor and his superior, the Master Observation Sheets are ready for the typist who copies all or a part of them in the form of write-up or instruction sheets. These instruction sheets may contain any necessary time-study information except base rates or piecework prices. After the instruction sheets have been typed and checked for typewritten errors, they are released for official use.

As stated, all time-study requests or questions should pass through the hands of the time-study supervisor. It is he who assigns all jobs to his various time-study men. He is responsible for the success or failure of time study. He becomes the watch-dog of costs. The cost office merely reflects costs, but the time-study supervisor is required to watch cost fluctuations as closely as the plant owners.

It may be safely stated that the time-study supervisor knows more than any one man regarding the plant as a whole. That is

why so many higher executives have been recruited from the ranks of time-study men.

In order to succeed, the time-study supervisor must do his work so thoroughly and satisfactorily that he will be ready for a higher promotion. As his time-study position continues to grow, he will require an assistant who will become his successor when a bigger job in the plant is offered to him.

The picking of an assistant is a most important task. A personal liking for a man is no good reason for selecting him as your assistant. A good assistant is one who possesses, among other things, the ability to do his own thinking. The fact that he can think straight should endow him with a degree of judgment and initiative that will enable him not only to relieve the time-study supervisor of a vast amount of detail but to carry on the latter's work after his promotion. Sometimes the field of candidates for possible successors to the job is so limited that the management is forced to go outside of the factory walls for a proper assistant.

As the plant grows, the time-study department must also expand to take care of the increased volume of work. Consequently, additional men must be trained for time study.

New men should be hired or transferred to the time-study department on a trial basis only after careful consideration has been given to their 80% – 20% possibilities. Each candidate for a position as T.S.M. should be subjected to an appraisement that includes, as a part of the specifications, the 24 qualities that were outlined in Chap. I. It is not to be expected that each new man will have developed all the characteristics to the required degree. If many of the traits are outstanding, other innate ones may manifest themselves during the trial period of employment.

Some of the 24 qualities which are being judged in a new man can be directly measured. For example, if the time-study supervisor is in doubt concerning the candidate's quality of self-control, he might arrange for another member of the department to provoke the candidate deliberately into losing his temper over some contested point. This means of gauging self-control or irritation might be repeated several times during the trial employment period. During that period, other tests can be made of the new man's possibilities. If he is found lacking

in some of the required traits, frank discussions with him may cause him to acquire and develop them to the status that is demanded.

The records of men who are selected from the shop personnel should be carefully analyzed before trial periods are granted to them. If their records are not above reproach so far as their potential time-study value is concerned, they should be promptly eliminated from consideration. Those who are selected for trial can be given jobs as clerks in the time-study department. While acting as clerks, they can be thoroughly trained on the following:

Quick and accurate use of slide rule.
Normalizing Shop Observation Sheets.
Preparation of Master Observation Sheets.
Figuration of Master Observation Sheets.
Handling of checking cards.
Computing Daily Posting Sheets.
Investigating factory complaints.

After learning these things, the green time-study men can be assigned to help the experienced time-study men in the work of collecting data on

Feeds and speeds.
Clocking of long P.M.T. cycles.
Incidentals.
Variables.
Counts.
Attention.
Interference.
Cleaning of machines.
Handling of materials.
Chip removal.
Sweeping.
Setups.
Inspection reports.
Salvage reports.
Scrap reports.
etc.

While associated with the regular time-study men, the new men are taught the use of the stop watch, rating, and other fundamental items of time study. To season their rating ability, they are required to time-study operations that have already been applied and to build C. Standards for them which are later compared with the official ones in use. As the new men further

progress, they are allowed to follow up applications, to make spot checks and production studies, to conduct simple tests, etc. As stated in earlier chapters, new time-study men can time machine-oiling, preparation, and other data for which slight inaccuracies of normals might be tolerated.

During the training period, the time-study supervisor should have periodical talks with the new men in order to learn how rapidly they are assimilating time-study principles and to instruct them further in the advanced steps of time study. It may be found that some of the new men might become better analysts on machine operations than on manual ones. Some may show greater aptitude in handling labor, and still others might be assigned to conducting tests for standardized data, etc. The possibilities of each new man can be learned by close supervision.

An extra chapter of substantial length might be written concerning the value of close supervision. This law holds true in any industry. Close supervision is imperative in the time-study department. That is one reason why the T.S.M. in charge is called the supervisor. In carrying on supervisory work, it is not always necessary to go into each detail in an exhaustive manner. The good supervisor knows how much of his time must be applied to his assistant and how much to all other persons over whom he has control.

For psychological reasons at least, time-study men should work factory hours. They should spend as much time as possible in the manufacturing departments and reserve the latter part of each afternoon to complete the figuration of their studies.

One of the most compatible means of encouraging a spirit of interest and enthusiasm on the part of plant officials who are not directly affected by time study is through periodical meetings. The time-study supervisor should get permission from his superior to hold occasional symposiums, at which time one or more foremen or other shop executives are in attendance. These meetings are held primarily to dispel the mistaken idea that time-study work is a secret profession which yields queer sounding phrases and doctrines that are mysteriously injected into the blood stream of manufacturing arteries. The second main reason for the meetings is to make every one "time-study conscious."

The first meeting might include the chief draftsman and the toolroom foreman. The time-study supervisor might show

them several time studies, where certain work elements call for normals that are too long for the work involved, and ask their opinions as to what better tools might be supplied. To minimize the useless waste of energy through extra walking, turning around, bending, abnormal postures, or unnecessary motions, many items of tool-equipment design might be discussed. Among them are

Cam levers on jigs or fixtures instead of wrenches.
Air-operated fixtures to clamp work.
Air-operated lines to clean out fixtures or tools.
Air-operated lines to remove work from punch-press dies.
Fixtures designed for automatic chip removal.
Fixtures designed to accommodate irregular sections, burrs, variations, etc., in order to obviate extra work.
Foot levers attached to fixtures in order to help handling.
Double-assembly fixtures that permit use of both of the operator's hands.

Referring to the last item, it is surprising how many tools or fixtures are designed so that they require the use of only one of the operator's hands. For example, the assembly of a small part might be completed while the operator holds the unit in his left hand. Although the right hand might be constantly busy adding and securing additional parts to the unit, the left hand, so far as time study is concerned, is useless. A bench fixture designed to hold the work would allow the operator to use both hands. Better still, a double fixture that holds two units will allow the operator to perform double movements, such as entering two nuts simultaneously, using two wrenches, etc.

At another meeting held for the discussion of inspection problems, the chief inspector discusses the loss, preservation, or betterment of quality in the applied operations. The cost of maintaining limits of accuracy on certain parts is an important item of interest and generally leads to suggestions that lower the prevailing manufacturing costs.

Still another meeting can be held with the production and plant engineers. Many interesting subjects can be discussed. Some of them are outlined in the next few paragraphs.

The modern method of machinery layout does not call for nice even aisles between machines positioned in military order, with each type of machine arranged in battery form. Such old-fashioned arrangements consume too much floor space and the

work-handling problems become costly items. The modern method of arranging machinery calls for layouts that permit the work to flow in one direction in progressive order. To this end, the machines, regardless of type, are placed in a sequence that agrees with the sequence of operation line-up sheets. The machines are located as closely as possible to each other so that the finished work of one operator is placed by him in a convenient spot for the next operator on the following operation. The time-study supervisor and the engineers discuss different types of gravity conveyors or chutes that convey the work to the next machine.

The general transportation of work is considered. Often, the time-study data reveals the economies to be had by using electric trucks, moving belts, or overhead conveyors that perhaps require large expenditures of money but yield savings that quickly absorb the capital investments which have been made for these new methods of transportation. Material-moving problems sometimes lead to complete revamping of machinery and equipment layout so that the raw materials are moved to the top floors of factory buildings and dropped by chutes or conveyors down through the different floors for their manufacturing treatment. In other words, the top floor becomes the raw storage which feeds the work through holes in the floor to the machinery on the different floors below.

Other topics for meetings are lighting arrangements, noise abatement, safety measures, working postures, and any other details that will conserve human energy.

To emphasize the value of motion-saving, one time-study supervisor studied the assembly operation of small electric motors. A careful time measurement was taken on the usual method of assembly with the customary material and tool arrangement. After the C. Standard had been built, he requested permission to experiment with the operation. First of all, he selected a bench of proper height and purchased an industrial chair, the design of which is outlined in Chap. XIII. Next, he had the draftsman design an air-operated holding fixture for the motor frame. The trays holding the small parts were arranged in a tipped position in a semicircular form in front of the operator. Thus, the radial position of the trays cut down extra reaching and the slanting position of the trays caused the

small work parts to gravitate continually toward the operator. Wrenches, screw drivers, and other tools that were constantly used were suspended by long coil springs over the fixture. The remaining tools were placed in holes or brackets that permitted the operator, in securing each tool, to grasp it in the exact position for immediate use. When the new method was finally operating satisfactorily, an 80 C. Hour operator was placed on the job and allowed to work a few days under the new method in order to establish a rhythm of movement before the job was time-studied.

Alongside the operator who was using the new method, the time-study supervisor positioned another 80 C. Hour operator who performed the same assembly operation by the old method. Thus, the before-and-after methods were placed side by side to show the great differences in output. This demonstration did much to make the whole personnel appreciate the values of motion and energy saving. To each witness, the time-study supervisor explained the wisdom of placing tools and work for convenient handling. He proved that the spring-suspended tools saved many hours of time per year because the use of a socket wrench, for example, required the observance of at least four fundamental motions: to find, to secure, to use, and to lay down, which were either eliminated or shortened by the use of the suspension scheme.

In other meetings, the time-study supervisor explains the use of the stop watch, the rating principles, the methods of count figuration, etc., and fully answers any questions that may be asked about time study.

Some plants organize time-study clubs which hold regular weekly meetings. A different chairman of the club is appointed every four months. This short period of time allows at least three different chairmen per year to be drawn from the shop-executive personnel. The foremen who appear to be only lukewarm toward time-study work generally become the most enthusiastic boosters after they have been appointed chairmen of the club.

The work of the T.S.M. never ends. Even after all applications have been made, there is work enough to keep a small-sized personnel in the time-study department. Some of the work items are: watching trend of C. Hours, investigating new methods, watching costs, checking up on complaints, insuring quality,

eliminating A.I.T., maintaining contact, etc. The never-ending work of collecting, establishing, and refining standardized data justifies the continual existence of the time-study department. Any plant that does not keep abreast of the changing economic conditions is sooner or later doomed to failure. Since changes in manufacturing practices must be made, the progressive manager of the plant finds that his greatest ally is the time-study department, because it can intelligently answer so many of his questions and can contribute so much to cost reduction.

There are still thousands of executives throughout the world who are not as yet receptive to modern time-study work. They feel that the old-fashioned methods which they use to set up time allowances are satisfactory, and they are prone to frown upon the idea of creating a regular time-study department. Not only do they feel that the trained T.S.M. will probably cause labor trouble in their plants, but also they believe that their manufacturing costs cannot be materially reduced.

This is the age of specialists. Time study requires trained specialists. The old feeling against the man with the stop watch has changed. Labor unions now recommend the use of trained time-study men because the unions know that time study does not make impossible demands. Therefore, the man in the shop often has more modern ideas than the plant owner.

Almost any progressive plant owner will consider the organization of a modern time-study department if he is convinced that he will secure proper returns on the money spent to create and maintain a time-study personnel. He is willing to be shown how manufacturing costs may be reduced but does not want spectacular means used to arrive at estimated savings.

One method of arriving at estimated savings in a plant without the use of a stop watch will be given in the form of the following example:

You were unable to secure a position as a T.S.M. in the small town where you live. The town has only one manufacturing plant, employing 200 direct operators, and manufactures, let us say, electric iceboxes. The plant operates on a piecework basis and specifies rates that were set by the departmental foremen.

Believing that this plant would prove a fertile field for your time-study training, you secured a job in it as a trucker. This position enabled you to witness the effective speed that was displayed by all the employees in the plant. It was your feeling that all the piece-work prices were loosely set.

This was confirmed from time to time by the statements made by the operators, who said that they could not exceed certain earnings for fear of piecework price cuts.

One evening you visited the factory manager in his home, advised him of your training, and requested his permission to submit a time-study plan and an estimate of possible manufacturing cost savings. You were told to accumulate your preliminary data without interfering with your trucking duties and, when they were completed, to visit the manager in his office.

Without attempting the use of the stop watch, you observed all the direct operators over a period of two weeks while you were loading and unloading your truck in the different departments. After you had selected 10 men whom you believed were representative of the average manual or H.M.T. operators, you observed these 10 men during the different parts of the day while you were performing your own work and prescribed Credor-hour performance ratings for them. Having satisfied yourself that your ratings for them were conservative, you made a list of the names and the ratings for the 10 men.

Your next step was to obtain from the manager the hourly wages paid to each of the 10 men and the number of hours that each man worked during the course of one month. Upon receipt of this information, you prepared Table 16, as shown below.

With reference to this table, the manager stated that the selection of the 10 men who were specified for the proposed estimate was not only fair, but

TABLE 16.—PROPOSED DIRECT-LABOR SAVINGS IN ELECTRIC ICEBOX PLANT

A	*B*	*C*	*D*	*E*	*F*
Man	C. Hour speed	Hours worked	Credors made	Earnings per hour, cents	Wages paid
1	40	200	8,000	40	$80.00
2	45	200	9,000	42	84.00
3	40	195	7,800	38	74.10
4	50	200	10,000	38	76.00
5	60	198	11,880	45	89.10
6	60	195	11,700	45	87.75
7	50	200	10,000	44	88.00
8	55	150	8,250	42	63.00
9	65	200	13,000	40	80.00
10	50	200	10,000	39	78.00
		1,938	99,630		$799.95

$$\frac{99{,}630 \text{ Credors}}{1{,}938 \text{ hr.}} = 51.4 \text{ present C. Hour}$$

$$\frac{\$799.95}{99{,}630} \times 100 = \$.803 \text{ present direct cost per 100 Credors}$$

that their hourly wages and working hours were representative of average conditions. You then explained the table in detail to him.

Column *B* represents the effective speed or output in Credors per hour for each of the 10 men. The ratings that were applied to them could be used as a gauge for the total 200 direct workers in the plant. Thus, in 200 hr. at 40 C. Hour speed, the No. 1 man produces 8,000 Credors per month; the No. 2 man, 9,000 Credors, etc. The 99,630 equivalent Credors divided by the total working hours per month indicates the 51.4 C. Hour that is to be improved. You explain that these men should perform at 80 C. Hour if given correct piecework prices.

Column *F*, the product of columns *C* and *E*, shows the monthly wages paid. The total of $799.95 is the actual money that was paid to the 10 men. Therefore, since it is the money paid for the 99,630 Credors that were produced, the present cost per 100 Credors must be the $.803 as shown. You explained that this present cost can be used as one of the factors in the proposed estimated savings. Instead of being conditioned on iceboxes produced, it is based on energy expended.

Had these 10 men produced 80 Credors of work per hour, in their total monthly hours (column *C*) they would have produced

$$80 \times 1{,}938 \text{ hr.} = 155{,}040 \text{ Credors}$$

instead of the 99,630 Credors as shown.

You explained that in order to induce the direct operators to become boosters of your plan, you would suggest an average 10 per cent increase in earnings for the 200 workers. Upon the basis of $799.95 plus 10 per cent = $879.95, call $880, the second factor or standard direct cost per 100 Credors is set up:

$$\frac{\$880}{155{,}040} \times 100 = \$.568 \text{ standard cost per 100 Credors}$$

Based on the present and proposed Credor costs, the estimated savings in percentage are

$$\frac{.803 - .568}{.803} = 29.3 \text{ per cent savings on direct labor cost over old piecework prices}$$

If the 99,630 Credors had been produced at the standard cost per Credor, a monthly saving on the 10 men would be as follows:

$$\begin{aligned} \text{Column } F &= \$799.95 \text{ total wages} \\ 99{,}630 \times \$.00568 &= \underline{\ \ 565.90} \text{ standard cost of Credors} \\ &\ \$234.05 \text{ savings on 10 men per month} \end{aligned}$$

With an explanation to the manager that you thought your proposed rough estimate of savings on 10 men could be called 85 per cent correct for

use in connection with all 200 men, you worked out the final yearly savings for direct labor as follows:

$$\frac{\$234.05 \times 12 \text{ months} \times 200 \text{ men} \times .85}{10 \text{ men}} = \$47{,}746.20 \text{ total direct labor savings per year}$$

In addition to this approximate $50,000-a-year savings on direct labor, you explained that it was your belief that the indirect pay roll could be reduced about one-third. Instead of the total of 90 indirect men, you thought that 60 indirect men, if given incentives, could easily perform the indirect work provided that they, too, worked at 80 C. Hour. Thus, the elimination of 30 indirect workers would result in about $35,000 additional savings per year.

You further stated that your proposed savings of about $85,000 a year were based on the methods that were currently used in the plant. Many simple labor-saving devices could be used to increase further the yearly savings if the manager was willing to allow you to create a time-study department in his plant.

Note that in the foregoing example the estimate was made without the use of a stop watch. The saving on the indirect labor (not explained) was obtained by use of the ratio method as outlined in Chap. XXI.

In making estimates on P.M.T. operations, it becomes necessary to take a few rough time measurements on certain machines which can be used as indexes. In such cases, the % N.W.T. for the machines must be recognized and unless the T.S.M. can readily see how the A.I.T. can be absorbed, he must set up the latter as attendant excess costs.

A time-study supervisor is a protagonist of efficiency. He should exhibit the same degree of energy in the operation of his time-study department as he advocates for others in the completion of their work.

Question

1. In this chapter it was stated that the time-study supervisor knows more than any one man regarding the plant as a whole. Name at least eight out of a possible list of at least twelve major subjects pertaining to general manufacture in some given plant with which the time-study supervisor must be thoroughly conversant.

Problems

2. You are required to make a diagnosis of the possible savings to be made in a small foundry that operates by day work and employes 50 molders who are considered direct operators. After casually observing all of them,

you decided to base your estimate of direct-labor costs on 10 per cent of the molders whom you believe are representative of the performance of the entire 50. Without timing any of the five selected men, you prescribed ratings for them that were, in your judgment, conservative estimates of their average effective Credor-hour performances. Your ratings of the five men are as follows:

Man	C. Hour Speed
1	40
2	35
3	45
4	45
5	40

The previous month was selected as a suitable period for the proposed savings. That month showed records of the same five men as follows:

Man	Hourly rate, cents	Hours worked
1	60	170.0
2	65	172.0
3	64	171.0
4	62	170.4
5	64	172.5

On the basis of the month's data, what is the operators' present C. Hour? What is the present direct cost per 100 Credors?

3. If you allowed 90 per cent for the correctness of your foundry diagnosis in Prob. 2 and based your figuration on 855.9 working hr. per month, what yearly foundry savings on direct labor could be obtained from 75 men who were given an average incentive of 15 per cent to cause them to produce at an 80 C. Hour average for the year?

4. You are asked to submit to the factory superintendent a rough estimate of the correct production per hour to be obtained from a semiautomatic machine in a department. There are many machines of this type, all doing the same job and each manned by an operator who cannot be given fill-in work or extra machines to run. Since the urgent need for the estimate does not allow you time enough to build a standard in the usual way for the machine operation, you spent but little time on the job. You first selected the operator whom you believed should be used for the estimate. On this operator, by means of two stop watches, you took cumulative watch readings on his Externals, Internals, and power-machine times. The data which you found are as follows:

P.M.T. = 3.3 min. (This machine time is satisfactory.)
Externals = 1.50 min. @ 50 C. Hour
Internals = 2.70 min. @ 50 C. Hour
Present average production = 12.5 pieces per hour
Down times negligible

Using the above data, you secured enough information for an approximately correct C. Standard. Since you included fatigue allowances for the actual watch readings for the manual elements, the normal that you allowed also include rest factors. *Questions:*

a. What is the C. Std. that you specified for the new production per hour?

b. What is the new production per hour? Show cycle to two places to right of decimal. Show production to two places to right of decimal.

c. What is the proposed % N.W.T.? Show to one place to right of decimal.

d. What is the theoretical number of machines that one man can operate? Show to two places to right of decimal.

e. Because each operator cannot be given extra work to absorb his A.I.T., it is decided to include the A.I.T. in the *a.* C. Std. What is the integrated C. Std. if the % N.W.T. is used as the divisor?

Answers to Question

1. In order for the time-study supervisor to handle his job properly, he must be thoroughly conversant with the following major subjects:

1. Economic functioning, output, and care of machines.
2. Knowledge of tool design and general equipment.
3. Manufacturing methods and operation layout.
4. Materials: quality, flow, inspection, and cost.
5. Understanding and proper handling of labor.
6. Production required of labor.
7. Value of energy conservation.
8. Factory overhead expenses and their control.
9. Plant policies and safety measures.
10. Manufacturing costs and their trends.
11. Reasons and remedies for cost fluctuations.
12. Time-study standardization.

In the second paragraph of Chap. I, the definition of time study was given. It covers machinery, methods, human endeavor, and surrounding conditions which are analyzed, measured, and standardized. The 12 major subjects above are only expansions of the definition and perhaps can be expanded into still more items.

If the time-study supervisor properly fulfills his duties, it can be said that he knows more than any other person in the plant concerning the various details connected with manufacture.

Answers to Problems

2.

Man	C. Hr. speed	Hours worked	Credors made	Hourly rate	Wages paid
1	40	170.0	6,800	60	$102.00
2	35	172.0	6,020	65	111.80
3	45	171.0	7,695	64	109.44
4	45	170.4	7,668	62	105.65
5	40	172.5	6,900	64	110.40
		855.9	35,083		$539.29

$$\frac{35{,}083}{855.9} = 41 \text{ present C. Hour}$$

$$\frac{\$539.29}{35{,}083} \times 100 = \$1.537 \text{ present direct cost per 100 Credors}$$

3.

$$80 \text{ C. Hour} \times 855.9 \text{ hr.} = 68{,}472 \text{ proposed Credors}$$

$$\frac{\$539.29 \times 1.15}{68{,}472} \times 100 = \$.906 \text{ standard cost per 100 Credors}$$

$$\begin{aligned} \text{Wages paid to five men based on 41 C. Hour} &= \$539.29 \\ \text{Standard total Credor Cost } 35{,}083 \times \$.00906 &= \underline{317.85} \\ \text{Savings on five men per month} &= \$221.44 \end{aligned}$$

$$\frac{\$221.44 \times 12 \text{ months} \times 75 \text{ men} \times .90}{5 \text{ men}}$$

$$= \$35{,}873.28 \text{ total direct-labor savings per year}$$

4. *a.* Externals 1.50 min. @ 50R. = 1.25 min. N. allowed
Internals 2.70 min. @ 50R. = 2.25 min. N. allowed
3.50 min. C. Std. per piece

b. External 1.25 min. × .75 R.F. = .9375 min. @ 80 C. Hour
P.M.T. = 3.3000 min.
4.2375 min. Call 4.24 min. cycle.

$$\frac{60}{4.24} = 14.15 \text{ pieces per hour production}$$

c. $\dfrac{3.5 \times 14.15}{80} = 61.9\%$ N.W.T.

d. $\dfrac{1.00}{.619} = 1.62$ machines operated

e. $\dfrac{\text{C. Std.}}{\%\text{ N.W.T.}} = \dfrac{3.50 \text{ min.}}{.619} = 5.65$ C. Std.

Proof, based on 80 C. Hour possibility:

$$\frac{80 \text{ C. Hour}}{\text{production per hour}} = \frac{80}{14.15} = 5.65 \text{ C. Std.}$$

Chapter XXIV

Chapter XXIV is the final examination. We feel confident you will not have any serious difficulty in passing it. Each of the 10 problems was selected as representative of one or more salient points in modern time-study procedure. None is tricky; some contain certain references to principles that will enable you to identify particular chapters, the reviewing of which will clear up any doubtful points.

If you solve the 10 problems readily and accurately, it does not necessarily indicate that the examination was comparatively simple. Instead, it means that you have learned the important phases of this primer and, as a result of this mastery, the examination was only a review for you of those important phases.

Should the examination prove difficult, this implies that you have not mastered all the book. In this case, you should review all or portions of the book after you have compared your answers with the model answers that are given.

To determine your final average grade, add the 23 credits you granted yourself for each chapter. To that total add the credit you allowed for the final examination and divide the sum by 24. As stated in the Introduction, a total credit of 70 points for the 24 chapters is the minimum passing grade.

CHAPTER XXIV

FINAL EXAMINATION

In this, the last chapter, 10 problems are given. They contain many of the fundamental principles of time study that were outlined in the previous chapters. Before you begin on the problems, it is suggested that you review parts of the book to clear up any doubts you may have as to the principles embodied in the examination problems. Allow 10 points for each problem correctly solved.

Problems

1. Cast-iron magneto brackets for gas engines are sent from the foundry to the rough-grinding or "snagging" room. The bracket castings are all the same size, but some of them require more snagging than others. This extra grinding is done because some of the castings have projecting sections of metal that are caused by improper sprue removal. Before delivering the castings, a foundry laborer knocks off the sprue from each casting. If the sprue does not break off flush with the casting surface, there is considerable excess stock to be ground off. The snagging of this sprue section is a major part of the grinding operation and, therefore, is considered an important variable.

Out of a quantity of 720 bracket castings that are sent to the snagging room, the T.S.M. found 180 good castings, 504 average, and 36 bad castings. He separated them into three piles according to their conditions and then timed and rated the grinder hand on the removal of the sprue projections on each of the condition classifications.

The T.S.M. obtained an average of .463 min. @ 70R. for the good castings; .568 min. @ 75R. for the average castings and 1.2 min. @ 60R. for the bad types. Based on these variables, what is the weighted average normal allowed per casting? Show normal to three places to right of decimal point.

2. With reference to the C.H.B. principles, solve the following:

a. An operation carrying a 24-ct. base rate is given to a new man who, at first, can average only 45 C. Hour. What is his proper starting rate?

b. A job that carries a 75-ct. base rate specifies a starting rate of 69 cts. What is the C.H.B.?

3. Build a C. Standard per piece that covers the manual operation of reaming a hole in valve guides according to the following:

Element	Description of elements	Actual, minutes	Rating	Rest, per cent
A	Up guide and place in vise..........	.028	75	10.0
B	Tighten vise......................	.030	80	13.0
C	Ream ⅜-in. hole..................	.160	75	12.0
D	Try gauge every second guide........	.100	60	10.0
E	Receam every fifth guide............	.144	75	10.0
F	Set reamer every 25th guide.........	.280	75	10.0
G	Away guide to barrel................	.018	80	9.5
H	Ring card every 250 guides..........	2.000	45	10.0

Show Allowed Normals to four places to right of decimal point.

a. What is the Allowed C. Standard shown to two decimal places?

b. What is the 60 C. Hour production?

c. What is the 80 C. Hour production?

d. What is the direct labor cost of the operation if a 42-ct. base rate is used?

4. Figure 46 shows an uncompleted Master Observation Sheet covering a gear-hobbing operation. Complete the figuration by using Duplicate Fig. 46. Elements *A*, *B*, *C*, ?, *L*, *M*, and *N* are Internals. The others are Externals. Carry Allowed Normals and cycles to three places to the right of decimal point. Also, show figuration for

a. What is the production per hour per machine? Show to two places to right of decimal point.

b. What is the Allowed C. Standard per gear? Show to one place to right of decimal point.

c. What is the % N.W.T.? Show to one place to right of decimal point.

d. How many machines can one operator handle? Show to two places to right of decimal point.

5. Two different time-study men build C. Standards for the same job. One obtains 2.5 min. C. Std. and the other obtains 2.65 min. C. Std. Is it advisable to allow an average of these two standards?

6. Figure 47 shows an uncompleted checking card for an operator assigned a C.H.B. It is noted that she completed 350 pieces of work, each carrying 1.2 min. C. Std., and that, aside from ½ hr. check-out time, she was on standard throughout the day. Complete the figuration of the checking card. Use Duplicate Fig. 47, Prob. 6. Direct Premium Credors are valued at 75 per cent of the Credor Cost. Fund Premium Credors are valued at 25 per cent of the Credor Cost.

7. In a pump factory, a lathe hand was also given a drill press to operate. Both the lathe and drill-press operations, as shown in Fig. 48, allowed A.I.T. During the day, the operator spent 15 min. in the first aid room receiving treatment for a finger-cut. Aside from this check-out time, he was on standard for the rest of the day. The lathe operation received an extra 10-min. allowance for waiting for material. Complete the figuration

(*Continued on page* 503)

THE BLANK CORPORATION
MASTER OBSERVATION SHEET

STUDY No. 1225

DEPT. NO. 3 DEPT. NAME MACHINE DATE WRITTEN AUG. 1, 19–.
PART NO. 1542 PART NAME FEED TUMBLER GEAR
OPERATION HOB 40 TEETH 20 P FOR GEAR GRINDER OPER. NO. 12
MATERIAL S.A.E. 1020 DROP FORGING. HEAT TREATMENT M.
OPERATOR JOHN DOE ~~FEMALE~~ MALE STARTED 7-25-19–. STOPPED 7-26-19– ELAPSED ½ HRS.
MACH. NO. 107 MACH. NAME BARBER COLMAN HOBBER.
TOOLS SEE SHEET 13 SPEED 160 RPM
FEED .050" PER REV.

CREDOR STD. PER %A.I.T. %N.W.T.

ELEMENT	REFERENCE	DESCRIPTION OF ELEMENTS	NORMAL	REST	COUNT	ALLOWED EXTERNAL	ALLOWED INTERNAL
A		Place gear & nut on slip arbor.	.239	13%			
B		Tighten nut.	.152	15			
C		White lead centers.	.120	10			
D		Move gear to machine.	.092	12			
E		Adjust in machine & position steady rest	.320	15			
F		Start machine & feed.	.140	10			
G		Hob 40 teeth for grinding finish. **	–	–			
H		Attention 5% of element G= @80R-		8			
I		Feed off return carriage.	.100	10			
J		Away steady rest.	.200	15			
K		Away gear from machine.	.060	12			
L		Loosen nut.	.123	13			
M		Remove gear.	.183	12			
N		Gage every 10th gear.	1.300	12			
O		Change hob every 300 gears.	14.500	13			
P		Allow 1.8% interference.					

REMARKS
** Use 8.91' + 4% belt slip = 9.26' PMT.

FOREMAN T.S.M. GEN. SUPT

FIG. 46.—Unfinished Master Observation Sheet relating to Prob. 4. Use the duplicate for figuration.

THE BLANK CORPORATION
MASTER OBSERVATION SHEET

STUDY No. 1225

DEPT. NO. 3 DEPT. NAME MACHINE DATE WRITTEN AUG. 1, 19—.

PART NO. 1542 PART NAME FEED TUMBLER GEAR

OPERATION HOB 40 TEETH 20 P FOR GEAR GRINDER OPER. NO. 12

MATERIAL S.A.E. 1020 DROP FORGING. HEAT TREATMENT M.

OPERATOR JOHN DOE ~~FEMALE~~ MALE STARTED 7-25-19—. STOPPED 7-26-19— ELAPSED ½ HRS.

MACH. NO. 107 MACH. NAME BARBER COLMAN HOBBER.

TOOLS SEE SHEET 13 SPEED 160 RPM FEED .050" PER REV.

CREDOR STD. PER %A.I.T. %N.W.T.

ELEMENT	REFERENCE	DESCRIPTION OF ELEMENTS	NORMAL	REST	COUNT	ALLOWED EXTERNAL	ALLOWED INTERNAL
A		Place gear & nut on slip arbor.	.239	13%			
B		Tighten nut.	.152	15			
C		White lead centers.	.120	10			
D		Move gear to machine.	.092	12			
E		Adjust in machine & position steady rest	.320	15			
F		Start machine & feed.	.140	10			
G		Hob 40 teeth for grinding finish. **	–	–			
H		Attention 5% of element G= @80R-		8			
I		Feed off return carriage.	.100	10			
J		Away steady rest.	.200	15			
K		Away gear from machine.	.060	12			
L		Loosen nut.	.123	13			
M		Remove gear.	.183	12			
N		Gage every 10th gear.	1.300	12			
O		Change hob every 300 gears.	14.500	13			
P		Allow 1.8% interference.					

REMARKS
** Use 8.9' + 4% belt slip = 9.26' PMT.

FOREMAN T.S.M. GEN. SUPT

Duplicate FIG. 46.—To be used by the reader for the figuration of Prob. 4.

THE BLANK CORPORATION

No. 373 DAILY CHECKING CARD

	IN	OUT		IN	OUT
A.M.	8:00	12:00	P.M.	1:00	5:00

NAME MARY SMITH DEPT. FINISHING DATE OCT. 1, 19—.

CODE	PART NO.	OPERATION	OPER. NO.	MACH. NO.	NO. OF PIECES	MACH. MIN.	N.W.T.	TOTAL WORK TIME	CREDORS STD.	CREDORS TOTAL	COST PER CREDOR	STD. COST
					350				1.2			
		Wait for work 30′										

MIN IN FACTORY ______

MIN. CREDIT ______

MIN ON STD. ______

TOTAL WORK TIME ______

A. I. T. ______

STD C'S WORKED ______

AVG CREDOR COST

CREDORS

______ STD. C'S

PREM. C'S

÷60=HRS ON STD. ______

BASE	OPER'S
.36	
C. HR	C.H.B
	55.0

TIME W'T STD. ______

IND. TIME ______

ALLOWED TIME ______

A.I.T. CREDIT ______

TOTAL CREDIT ______

C =STD ______

TOTAL

CALL ______

WAGE ______

PREM. ______

FUND ______

TOTAL ______

FIG. 47.—Unfinished checking card relating to Prob. 6. Use the duplicate for figuration.

THE BLANK CORPORATION

DAILY CHECKING CARD

No. 373

NAME MARY SMITH

DEPT. FINISHING

DATE OCT. 1, 19—.

A.M. IN	A.M. OUT	P.M. IN	P.M. OUT
8:00	12:00	1:00	5:00

CODE	PART NO.	OPERATION	OPER. NO.	MACH. NO.	NO. OF PIECES	MACH. MIN.	N.W.T.	TOTAL WORK TIME	CREDORS STD.	CREDORS TOTAL	COST PER CREDOR	STD. COST
					350				1.2			
		Wait for work 30'										

MIN IN FACTORY ______

MIN. CREDIT ______

MIN ON STD. ______

TOTAL WORK TIME ______

A. I. T. ______

STD C'S WORKED ______

AVG CREDOR COST ______

CREDORS

______ STD. C'S

PREM. C'S

÷60=HRS ON STD. ______

BASE	OPER'S
.36	
C. HR	**C.H.B**
	55.0

TIME W'T STD. ______

IND. TIME ______

ALLOWED TIME ______

A.I.T. CREDIT ______

TOTAL CREDIT ______

C =STD ______

TOTAL ______

CALL ______

WAGE ______

PREM. ______

FUND ______

TOTAL ______

Duplicate FIG. 47.—To be used by the reader for the figuration of Prob. 6.

THE BLANK CORPORATION

DAILY CHECKING CARD

No. 759

	IN	OUT		IN	OUT
A.M.	8:00	12:00	P.M.	1:00	5:00

NAME Albert Doe DEPT. Machine DATE Feb. 16, 19—.

CODE	PART NO.	OPERATION	OPER. NO.	MACH. NO.	NO. OF PIECES	MACH. MIN.	N.W.T.	TOTAL WORK TIME	CREDORS STD.	CREDORS TOTAL	COST PER CREDOR	STD. COST
		Lathe	3	150	3		31.0%		55.0			
		Drill Press	5	84	180		60.0		2.0			
		First Aid 15′										
		Lathe 10′ wait for work										

MIN. IN FACTORY ______

MIN. CREDIT ______

MIN. ON STD. ______

TOTAL WORK TIME ______

A. I. T. ______

STD. C'S WORKED ______

AVG. CREDOR COST

CREDORS

______ STD. C'S

PREM. C'S

÷60=HRS. ON STD. ______

BASE	OPER'S
48	
C. HR.	C.H.B.

TIME W'T STD. ______

IND. TIME ______

ALLOWED TIME ______

A.I.T. CREDIT ______

TOTAL CREDIT ______

C. =STD. ______

TOTAL

CALL ______

WAGE ______

PREM. ______

FUND ______

TOTAL ______

Fig. 48.—Unfinished checking card relating to Prob. 7. Use the duplicate for figuration.

THE BLANK CORPORATION

DAILY CHECKING CARD

No. 759

NAME Albert Doe DEPT. Machine DATE Feb. 16, 19—.

	IN	OUT		IN	OUT
A.M.	8:00	12:00	P.M.	1:00	5:00

CODE	PART NO.	OPERATION	OPER. NO.	MACH. NO.	NO. OF PIECES	MACH. MIN.	H.W.T.	TOTAL WORK TIME	CREDORS STD.	CREDORS TOTAL	COST PER CREDOR	STD. COST
		Lathe	3	150	3		31.0%		55.0			
		Drill Press	5	84	180		60.0		2.0			
		First Aid 15′										
		Lathe 10′ wait for work										

MIN. IN FACTORY ______

MIN. CREDIT ______

MIN. ON STD. ______

TOTAL WORK TIME ______

A. I. T. ______

STD. C'S WORKED ______

AVG. CREDOR COST

CREDORS

______ STD. C'S

PREM. C'S

÷60=HRS. ON STD. ______

BASE	OPER'S
.48	
C. HR.	C.H.B.

TIME W'T STD. ______

IND. TIME ______

ALLOWED TIME ______

A.I.T. CREDIT ______

TOTAL CREDIT ______

C. = STD. ______

TOTAL

CALL ______

WAGE ______

PREM. ______

FUND ______

TOTAL ______

Duplicate Fig. 48.—To be used by the reader for the figuration of Prob. 7.

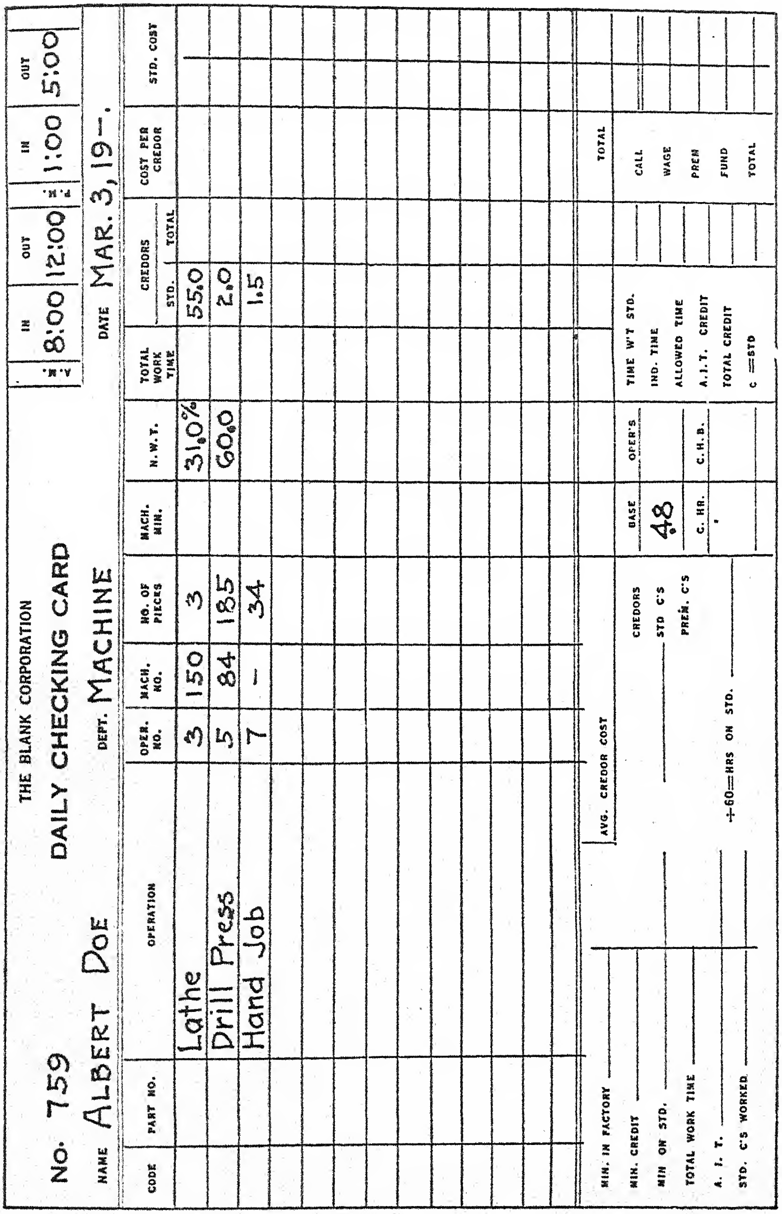


FIG. 49.—Unfinished checking card relating to Prob. 8. Use the duplicate for figuration.

THE BLANK CORPORATION

DAILY CHECKING CARD

No. 759

NAME ALBERT DOE

DEPT. MACHINE

DATE MAR. 3, 19—.

A.M. IN	A.M. OUT	P.M. IN	P.M. OUT
8:00	12:00	1:00	5:00

CODE	PART NO.	OPERATION	OPER. NO.	MACH. NO.	NO. OF PIECES	MACH. MIN.	N.W.T.	TOTAL WORK TIME	CREDORS STD.	CREDORS TOTAL	COST PER CREDOR	STD. COST
		Lathe	3	150	3		31.0%		55.0			
		Drill Press	5	84	185		60.0		2.0			
		Hand Job	7	—	34				1.5			

MIN. IN FACTORY ______

MIN. CREDIT ______

MIN ON STD. ______

TOTAL WORK TIME ______

A. I. T. ______

STD. C'S WORKED ______

AVG. CREDOR COST

CREDORS

______ STD C'S

PREM. C'S

÷60=HRS ON STD. ______

BASE	OPER'S
48	
C. HR.	C.H.B.

TIME W'T STD.

IND. TIME

ALLOWED TIME

A.I.T. CREDIT

TOTAL CREDIT

C =STD

TOTAL

CALL

WAGE

PREM

FUND

TOTAL

Duplicate FIG. 49.—To be used by the reader for the figuration of Prob. 8.

THE BLANK CORPORATION

No. 397 DAILY CHECKING CARD

A.M. IN	A.M. OUT	P.M. IN	P.M. OUT
8:00	12:00	1:00	3:00

NAME John Doe DEPT. Assembly DATE Aug. 20, 19—.

CODE	PART NO.	OPERATION	OPER. NO.	MACH. NO.	NO. OF PIECES	MACH. MIN	N.W.T.	TOTAL WORK TIME	CREDORS STD.	CREDORS TOTAL	COST PER CREDOR	STD. COST
	437G	Assemble	21		30				2.5			
	438G	"	26		24				3.0			
	731F	"	23		9				9.0			
	693H	"	19		180				.4			
		Wait for work 15'										
		Day work 15'										

MIN. IN FACTORY ——
MIN. CREDIT ——
MIN. ON STD. ——
TOTAL WORK TIME ——
A. I. T. ——
STD. C'S WORKED ——

AVG. CREDOR COST

CREDORS
—— STD. C'S
PREM. C'S

÷60=HRS. ON STD. ——

BASE	OPER'S
.78	
C. HR.	C.H.B.

TIME W'T STD. ——
IND. TIME ——
ALLOWED TIME ——
A.I.T. CREDIT ——
TOTAL CREDIT ——
C. = STD. ——

TOTAL
CALL ——
WAGE ——
PREM. ——
FUND ——
TOTAL ——

FIG. 50.—Unfinished checking card relating to Prob. 9. Use the duplicate for figuration.

THE BLANK CORPORATION

DAILY CHECKING CARD

	IN	OUT		IN	OUT
A.M.	8:00	12:00	P.M.	1:00	3:00

.No. 397

NAME John Doe DEPT. Assembly DATE Aug. 20, 19—.

CODE	PART NO.	OPERATION	OPER. NO.	MACH. NO.	NO. OF PIECES	MACH. MIN	N.W.T.	TOTAL WORK TIME	CREDORS STD.	CREDORS TOTAL	COST PER CREDOR	STD. COST
	437G	Assemble	21		30				2.5			
	438G	"	26		24				3.0			
	731F	"	23		9				9.0			
	693H	"	19		180				.4			
		Wait for work 15'										
		Day work 15'										

MIN. IN FACTORY ______

MIN. CREDIT ______

MIN. ON STD. ______

TOTAL WORK TIME ______

A. I. T. ______

STD. C'S WORKED ______

AVG. CREDOR COST

CREDORS

______ STD. C'S

PREM. C'S

÷60=HRS. ON STD. ______

BASE	OPER'S
.78	
C. HR.	C.H.B.

TIME W'T STD. ______

IND. TIME ______

ALLOWED TIME ______

A.I.T. CREDIT ______

TOTAL CREDIT ______

C. = STD. ______

TOTAL

CALL ______

WAGE ______

PREM. ______

FUND ______

TOTAL ______

Duplicate Fig. 50.—To be used by the reader for the figuration of Prob. 9.

of the checking card shown in Fig. 48. Use Duplicate Fig. 48, Prob. 7. Direct Premium Credors are valued at 75 per cent of the Credor Cost. Fund Premium Credors are valued at 25 per cent of the Credor Cost.

8. In the same pump factory, the same lathe hand as in Prob. 7 ran his lathe and the drill press and also performed a fill-in job. The number of pieces completed and their C. Standards for the three different jobs are shown in Fig. 49. The supply of the hand-job operation lasted only 6 hr., after which A.I.T. became due and payable. Using Duplicate Fig. 49, Prob. 8, complete the figuration of the checking card shown in Fig. 49. The premium and fund values are the same as in Prob. 7.

9. The checking card Fig. 50 shows a 78-ct. assembler's performance on four assembly jobs, each one carrying a separate C. Std. Using Duplicate Fig. 50, Prob. 9, complete the figuration of John Doe's performance according to Fig. 50.

10. You are called upon to build a factory overhead rate in a textile-mill department. You decide to set it up by use of the rated method. The mill operates 6 hr. per day. You have learned the number of hours that each indirect worker spends in the department, you have timed and rated all these indirect workers, and your basic data covering their performances are as follows:

Duty	Hours in dept.	Rating	Base rate
Overseer	3.0	40	$3.00
Second hand	6.0	60	1.50
Fixer	6.0	55	.78
Fixer	5.5	55	.75
Oiler	3.6	40	.42
Bander	6.0	75	.39
Trucker	2.0	65+	.36
Bobbin boy	2.4	65	.30
Roving boy	6.0	80	.30
Clerk	4.0	45	.48
Sweeper	2.8	45	.36

After you had obtained the above preliminary data and worked out the total indirect cost per day, you looked up the recent C. Hour performances of the direct operators who were serviced by the above indirect workers and found the direct-worker averages per day as given in the table on the following page. *Questions:*

a. What is the standard indirect cost per 100 Credors, based on the 96 direct operators? Show to two places to right of decimal point.

b. What is the standard hour factor per Credor produced? Show to six places to right of decimal point.

c. If the overseer obtains an 80 average Credor-hour performance from his 96 direct operators, how many standard indirect hours is he allowed per 40-hr. week for correct manufacturing practice? Show even hours as answer.

Direct operators	Average C. Hour	Daily hours on standard
30	80	6.0
5	85	6.0
15	75	5.9
24	70	6.0
6	65	6.6
3	55	5.8
4	50	5.4
2	45	6.0
2	90	5.7
5	59.1	5.6
96		

d. What is the cost of the hours in (*c*)?

Answers to Problems

1.

Good.......................... $^{180}/_{720}$ = 25 per cent
Average....................... $^{504}/_{720}$ = 70 per cent
Bad........................... $^{36}/_{720}$ = 5 per cent
100 per cent

Good... .463 min. @ 70R. = .54 min. N. × .25 = .135 min. partial normal
Average .568 min. @ 75R. = .71 min. N. × .70 = .497 min. partial normal
Bad.... 1.200 min. @ 60R. = 1.20 min. N. × .05 = .060 min. partial normal
Weighted average normal.................. = .692 min. per casting

2.

(*a*) \$.24 × 45/60 = \$.18 starting rate
(*b*) \$.75/60 = \$.0125 Credor Cost. \$.69/.0125 = 55.2 C.H.B.

3.

Element	Actual, minutes	Rating	Normal, minutes	Rest, per cent	Count	Allowed Normal, minutes
A	.028	75	.035	10	1	.0385
B	.030	80	.040	13	1	.0452
C	.160	75	.200	12	1	.2240
D	.100	60	.100	10	½	.0550
E	.144	75	.180	10	⅕	.0396
F	.280	75	.350	10	1/25	.0154
G	.018	80	.024	9.5	1	.0263
H	2.000	45	1.500	10	1/250	.0066
						.4506

(*Continued on page* 510)

THE BLANK CORPORATION
MASTER OBSERVATION SHEET

STUDY No. 1225

DEPT. NO. 3 DEPT. NAME MACHINE DATE WRITTEN AUG. 1, 19–.

PART NO. 1542 PART NAME FEED TUMBLER GEAR

OPERATION HOB 40 TEETH 20 P FOR GEAR GRINDER OPER. NO 12

MATERIAL S.A.E. 1020 DROP FORGING. HEAT TREATMENT M

OPERATOR JOHN DOE ~~FEMALE~~ MALE STARTED 7-25-19- STOPPED 7-26-19- ELAPSED ½ HRS.

MACH. NO. 107 MACH. NAME BARBER COLMAN HOBBER

TOOLS SEE SHEET 13 SPEED 160 RPM FEED .050" PER REV.

CREDOR STD. 3.0 PER GEAR %A.I.T. 78.1% %N.W.T. 21.9%

ELEMENT	REFERENCE	DESCRIPTION OF ELEMENTS	NORMAL	REST	COUNT	ALLOWED EXTERNAL	ALLOWED INTERNAL
A		Place gear & nut on slip arbor.	.239	13%	1		.270
B		Tighten nut.	.152	15	1		.175
C		White lead centers.	.12	10	1		.132
D		Move gear to machine.	.092	12	1	.103	
E		Adjust in machine & position steady rest.	.32	15	1	.368	
F		Start machine & feed.	.14	10	1	.154	
G		Hob 40 teeth for grinding finish PMT = 9.26'		–	–		
H		Attention 5% of element G = 9.26 x .05 @ 80R =	.617	8			.666
I		Feed off return carriage.	.10	10	1	.110	
J		Away steady rest.	.20	15	1	.230	
K		Away gear from machine.	.06	12	1	.067	
L		Loosen nut.	.123	13	1		.139
M		Remove gear.	.183	12	1		.205
N		Gage every 10th gear.	1.30	12	$\frac{1}{10}$		.146
O		Change hob every 300 gears.	14.50	13	$\frac{1}{300}$	.055	
P		Allow 1.8% interference.				1.087	
		Total externals @ 80 = 1.087 x .75 RF = .815					
		Element G PMT = 9.26					
		Trial cycle 10.075 x .018 interference				.181	
		Add on actual interference .181				1.268	
		Revised cycle 10.256					1.733
							1.268
		$\frac{60}{10.256}$ = 5.85 gears per hour					3.001
		$\frac{5.85 \times 3.0'}{80}$ = 21.9% N.W.T.	Call C. Std. - 3.0'				
		$\frac{1}{.219}$ = 4.57 machines operated.					

REMARKS

FOREMAN T.S.M. GEN. SUPT.

FIG. 51.—Showing completed figuration of Prob. 4.

THE BLANK CORPORATION

DAILY CHECKING CARD

No. 373

	IN	OUT		IN	OUT
A.M.	8:00	12:00	P.M.	1:00	5:00

NAME MARY SMITH DEPT. FINISHING DATE OCT. 1, 19—.

CODE	PART NO.	OPERATION	OPER. NO.	MACH. NO.	NO. OF PIECES	MACH. MIN.	H.W.T.	TOTAL WORK TIME	CREDORS STD.	CREDORS TOTAL	COST PER CREDOR	STD. COST
					350				1.2	420	.006	2 520
		Wait for work 30'									.0055	165
		480' in shop										
		30' delay										
		450 × 55 = 413' on C.H.B.										
		60										

MIN. IN FACTORY	480	
MIN. CREDIT	30	
MIN. ON STD.	450 =	413
TOTAL WORK TIME		
A. I. T.		
STD. C'S WORKED		450

AVG. CREDOR COST

420	CREDORS	
413	STD. C'S	
7	PREM. C'S	
÷60=HRS. ON STD.	7.5	

BASE	OPER'S
.36	.33
C. HR.	C.H.D.
56.0	55.0

TIME W'T STD.	
IND. TIME	
ALLOWED TIME	30
A.I.T. CREDIT	
TOTAL CREDIT	
C = STD.	

TOTAL	2 685
CALL	2 68
WAGE	2 64
PREM.	03
FUND	01
TOTAL	2 68

FIG. 52.—Showing completed figuration of Prob. 6.

THE BLANK CORPORATION

DAILY CHECKING CARD

No. 759

NAME ALBERT DOE   DEPT. MACHINE   DATE FEB. 16, 193–.

	IN	OUT		IN	OUT
A.M.	8:00	12:00	P.M.	1:00	5:00

CODE	PART NO.	OPERATION	OPER. NO.	MACH. NO.	NO. OF PIECES	MACH. MIN.	N.W.T.	TOTAL WORK TIME	CREDORS STD.	CREDORS TOTAL	COST PER CREDOR	STD. COST
		Lathe	3	150	3	455	31.0%	141	55.0	165	.008	1 32
		Drill Press	5	84	180	465	60.0	279	2.0	360	.008	2 88
		First Aid 15'									.008	12
		Lathe 10' wait for work										
		A.I.T. = 45'									.008	36
								420		525	TOTAL	4 68

MIN. IN FACTORY	480	
MIN. CREDIT	15	
MIN. ON STD.	465	465
TOTAL WORK TIME	420	
A. I. T.		45
STD. C'S WORKED		420

AVG. CREDOR COST

525	CREDORS
420	STD. C'S
105	PREM. C'S
÷60=HRS. ON STD.	7.0

BASE	OPER'S
48	
C. HR.	C.H.B.
75.0	

TIME W'T STD.	
IND. TIME	
ALLOWED TIME	15
A.I.T. CREDIT	45
TOTAL CREDIT	60
C. = STD.	

CALL	
WAGE	3 84
PREM.	63
FUND	21
TOTAL	4 68

FIG. 53.—Showing completed figuration of Prob. 7.

THE BLANK CORPORATION

DAILY CHECKING CARD

No. 759

NAME ALBERT DOE DEPT. MACHINE DATE MAR. 3, 193–.

	IN	OUT		IN	OUT
A.M.	8:00	12:00	P.M.	1:00	5:00

CODE	PART NO.	OPERATION		OPER. NO.	MACH. NO.	NO. OF PIECES	MACH. MIN.	H.W.T.	TOTAL WORK TIME	CREDORS STD.	CREDORS TOTAL	COST PER CREDOR	STD. COST
		Lathe	8 hrs	3	150	3	480	31.0%	149	55.0	165	.008	1 320
		Drill Press	8 "	5	84	185	480	60.0	288	2.0	370	"	2 960
		Hand	6 "	7	–	34	360	9.0	32	1.5	51	"	408
								100.0%					
		A.I.T. = 11′										"	088
									469		586	TOTAL	4 776

MIN. IN FACTORY 480

MIN. CREDIT –

MIN. ON STD. 480 | 480

TOTAL WORK TIME 469

A. I. T. | 11

STD. C'S WORKED | 469

AVG. CREDOR COST

586	CREDORS
469	STD C'S
117	PREM. C'S

÷60=HRS. ON STD. 7.82

BASE	OPER'S
48	
C. HR.	C.H.B.
75.0	

TIME W'T STD.	
IND. TIME	
ALLOWED TIME	
A.I.T. CREDIT	.11
TOTAL CREDIT	
C = STD.	

CALL	4 77
WAGE	3 84
PREM.	70
FUND	23
TOTAL	4 77

FIG. 54.—Showing completed figuration of Prob. 8.

THE BLANK CORPORATION

DAILY CHECKING CARD

No. 397

	IN	OUT		IN	OUT
A. M.	8:00	12:00	P. M.	1:00	3:00

NAME JOHN DOE DEPT. ASSEMBLY DATE AUG. 20, 19—.

CODE	PART NO.	OPERATION	OPER. NO.	MACH. NO.	NO. OF PIECES	MACH. MIN.	N.W.T	TOTAL WORK TIME	CREDORS STD.	CREDORS TOTAL	COST PER CREDOR	STD. COST
	437G	Assemble	21		30				2.5	75	.013	975
	438G	"	26		24				3.0	72	"	936
	731F	"	23		9				9.0	81	"	1 053
	693H	"	19		180				.4	72	"	936
		Wait for work 15′										195
		Day work 15′										195
		C = Std. = 30′										390
										300	TOTAL	4 68

MIN. IN FACTORY 360
MIN. CREDIT 30
MIN. ON STD. 330
TOTAL WORK TIME
A. I. T.
STD. C'S WORKED 330

AVG. CREDOR COST

300 CREDORS
330 STD. C'S
C. = Std. = 30 PREM. C'S
÷60 = HRS. ON STD. 5.5

BASE	OPER'S
.78	
C. HR.	C:H.B.
54.5	

TIME W'T STD.	15
IND. TIME	
ALLOWED TIME	15
A.I.T. CREDIT	
TOTAL CREDIT	30
C = STD.	30

CALL	
WAGE	4 68
PREM.	—
FUND	—
TOTAL	

FIG. 55.—Showing completed figuration for Prob. 9.

(a) Call .45 min. C. Std. per guide.
(b) 60 min./.45 min. = 133 guides per hour production @ 60 C. Hour
(c) 80 min./.45 min. = 178 guides per hour production @ 80 C. Hour
(d) \$.42/60 × .45 min. = \$.00315 direct labor cost of operation

4. Figure 51 shows the completed figuration for the gear-hobbing operation:

a. If the revised cycle of 10.256 min. is used, a production of 5.85 gears per hour can be obtained.

b. The 3.001 is called 3 min. Allowed C. Std. per gear.

c. The 21.9% N.W.T. was determined by regular formula.

d. 4.57 machines can be operated.

5. Yes. An average can be used because it was stated on page 76 that the limits of error on ratings between two time-study men should not exceed 7 per cent variance.

$$\frac{2.50}{2.65} = 94.4 \text{ per cent correct (93 per cent minimum agreement allowed)}$$

6. Figure 52 shows the completed figuration of the checking card. Since the base rate is 36 cts. and since the operator is given 55 C.H.B., her starting rate is 33 cts. per hour. The costing of the items are in accordance with the instructions given on page 326 in Chap. XVII.

7. Figure 53 shows the completed figuration of the checking card. Both machines were down for 15 min. because of first-aid treatment; therefore the operator had only 465 min. to devote to his work.

As the lathe operation had to wait 10 min. (not costed because of A.I.T. allowance) for material, its net time for operation was only 455 min. The 31% N.W.T. attached to this operation allowed only 141 min. of working time to the operator.

Although the drill press has 465 min. in which to operate, the operator was allowed only 279 min. working time because of the 60% N.W.T.

The remainder of the card figuration will not be explained because it only follows the principle that was outlined in Chap. XII covering A.I.T. figuration.

8. Figure 54 shows the completed checking card. In adherence to the A.I.T. principles, there was no A.I.T. during the 6 hr. that the operator had a supply of the hand-job parts. However, since the lathe and drill-press operations required 31 per cent + 60 per cent = 91% N.W.T., only 9 per cent of the 6 hr. was available for the operator to complete the 34 hand-job parts.

9. Figure 55 shows a subnormal performance for the operator. His 54.5 C. Hour resulted in 30 Credors to equal standard. Because of this, he made no premium, being paid \$4.68 base wage for his 6 hr. in the plant.

10. The figuration for the textile-mill department is shown in the table at the top of page 511.

The total cost of \$24.90 becomes the dividend in the formula used to find the standard indirect cost per 100 Credors. The divisor is the total average

Duty	Hours in dept.	Rating	Normal hours	80 C. Hours required	Base rate	Cost per day
Overseer	3.0	40	2.00	1.50	$3.00	$4.500
Second hand	6.0	60	6.00	4.50	1.50	6.750
Fixer	6.0	55	5.50	4.13	.78	3.221
Fixer	5.5	55	5.04	3.78	.75	2.835
Oiler	3.6	40	2.40	1.80	.42	.756
Bander	6.0	75	7.50	5.63	.39	2.196
Trucker	2.0	65+	2.25	1.69	.36	.608
Bobbin boy	2.4	65	2.60	1.95	.30	.585
Roving boy	6.0	80	8.00	6.00	.30	1.800
Clerk	4.0	45	3.00	2.25	.48	1.080
Sweeper	2.8	45	2.10	1.58	.36	.569
				34.81		$24.900

daily Credors produced by the 96 direct operators during the period that the indirect workers were being timed and rated. The performances of the direct workers are as follows:

Direct operators	Average C. Hour	Daily hours on standard	Total Credors produced
30	80.0	6.0	14,400
5	85.0	6.0	2,550
15	75.0	5.9	6,638
24	70.0	6.0	10,080
6	65.0	6.6	2,574
3	55.0	5.8	957
4	50.0	5.4	1,080
2	45.0	6.0	540
2	90.0	5.7	1,026
5	59.1	5.6	1,655
96			41,500

(*a*) $\frac{\$24.90}{41{,}500} \times 100$ = \$.06 standard indirect cost per 100 Credors

(*b*) $\frac{34.81}{41{,}500}$ = .000839 standard hour factor per Credor produced

(*c*) 96×80 C. Hour $\times$ 40 hr. $\times$ .000839 = 258 standard indirect hr. allowed

(*d*) $\frac{\$24.90}{34.81} \times 258$ hr. = \$184.55 cost of standard weekly indirect hours

INDEX